The Angle Orthodontist

October • 1961

Published Quarterly by
The Edward H. Angle Society of Orthodontia

Published Quarterly by the
EDWARD H. ANGLE SOCIETY OF ORTHODONTIA
Zuelke Building, Appleton, Wisconsin
Subscription Rates: $6.00 per year, Canada $6.25,
other foreign countries $6.50.

☆ ☆ ☆

Copyright, 1946, by the Edward H. Angle Society of Orthodontia

Second Class Postage paid at Appleton, Wisconsin

The Angle Orthodontist

October 1961

Volume 31, Number 4

Contents

207 • Changes of Intermolar and Intercuspid Distances Following Orthodontic Treatment
Sherwood R. Steadman, D.D.S., M.S.

216 • A Comparative Study of Cephalometric Superimposition
Earl O. Bergersen, D.D.S., M.S.D.

230 • The Relationship Between Eruption, Calcification, and Crowding of Certain Mandibular Teeth
Richard Eldon Bradley, D.D.S., M.S.

237 • Problems and Promises of Basilar View Cephalograms
H. Berger, Dr. Med. Dent.

246 • Reduction and Fixation of Facial Fractures
Robert F. Schoenwetter, D. D. S., M.S.

257 • Effect of Vitamin C on the Mobility and Stability of Guinea Pig Incisors Under the Influence of Orthodontic Force
J. M. McCanlies, D.D.S., C. M. Alexander, D.D.S., J. H. Robnett, D.D.S., W. B. Magness, D.D.S.

264 • Obituary

266 • Book Review

FREDERICK BOGUE NOYES

1872 - 1961

Changes Of Intermolar And Intercuspid Distances Following Orthodontic Treatment

SHERWOOD R. STEADMAN, D.D.S., M.S.
St. Paul, Minnesota

To all orthodontists the question arises sooner or later concerning the permanency of changes produced during the period of orthodontic treatment. This study was undertaken to answer this question.

HISTORY

History records many who have studied the face, teeth and jaws. Most were trying to establish a "norm" or to see the manner in which a "normal" child's face, jaw and teeth grow. One of the first was John Hunter, 1771, who set down the principles of jaw growth, alveolar bone growth, and dental arch form. He was followed by Fox in 1790 who published a text showing the manner in which (1) the mandible grows, (2) the permanent teeth replace the deciduous teeth, and (3) space is obtained so that the molars may successively erupt. In 1891 Charles Tomes published a "Study of Growth of Jaws", and similarly studies by Zsigmondy 1890 and Wallace in 1911 and 1927 presented studies on normal jaw growth. Colyer in 1920 was the first to record a study of changes in the dental arches during childhood. In 1929 Lewis and Lehman published "Observations of the Growth Changes of the Teeth and Dental Arches". B. Holly Broadbent, 1937, published the patterns by which the faces, jaws, teeth, and dental arches of healthy children grow; this was obtained from material which he collected at the Bolton Foundation. In 1940 Cohen published "Growth and Development of Dental Arches in Children". Brodie, in 1948, wrote "Growth of the Jaws and the Eruption of the Teeth". In 1950 Woods compared the dental arch with facial width. In 1953 Scott reported on individual variation in facial growth.

In none of the literature was the author able to find any definitive study showing the amount the intermolar and intercuspid distances changed during orthodontic treatment, orthodontic retention, and thereafter. Accordingly the following study was undertaken to obtain such information. Then Walter, 1951, presented a report on this very same subject. It was decided, nevertheless, to continue as planned and to present the findings in a different manner.

PROCEDURE

From the files of the orthodontic department of the University of Minnesota the first thirty-one records containing models before orthodontic treatment, at the completion of orthodontic treatment, and one or more years after termination of retention were used for this study. The beaks of a Boley micrometer were filed to a knife edge at the measuring surfaces. Using this micrometer measurements in tenths of millimeters were made of intermolar and intercuspid distances between the central fossae of the molars and the center of the tips of the cuspids. These measurements were made on the plaster models and recorded on a separate sheet for each patient. This record sheet contained spaces for the measurements of the models before orthodontic treat-

Read before the Mid-Western component of the Angle Society, January, 1960.

FREDERICK BOGUE NOYES

1872 - 1961

Changes Of Intermolar And Intercuspid Distances Following Orthodontic Treatment

SHERWOOD R. STEADMAN, D.D.S., M.S.
St. Paul, Minnesota

To all orthodontists the question arises sooner or later concerning the permanency of changes produced during the period of orthodontic treatment. This study was undertaken to answer this question.

HISTORY

History records many who have studied the face, teeth and jaws. Most were trying to establish a "norm" or to see the manner in which a "normal" child's face, jaw and teeth grow. One of the first was John Hunter, 1771, who set down the principles of jaw growth, alveolar bone growth, and dental arch form. He was followed by Fox in 1790 who published a text showing the manner in which (1) the mandible grows, (2) the permanent teeth replace the deciduous teeth, and (3) space is obtained so that the molars may successively erupt. In 1891 Charles Tomes published a "Study of Growth of Jaws", and similarly studies by Zsigmondy 1890 and Wallace in 1911 and 1927 presented studies on normal jaw growth. Colyer in 1920 was the first to record a study of changes in the dental arches during childhood. In 1929 Lewis and Lehman published "Observations of the Growth Changes of the Teeth and Dental Arches". B. Holly Broadbent, 1937, published the patterns by which the faces, jaws, teeth, and dental arches of healthy children grow; this was obtained from material which he collected at the Bolton Foundation. In 1940 Cohen published "Growth and Development of Dental Arches in Children". Brodie, in 1948, wrote "Growth of the Jaws and the Eruption of the Teeth". In 1950 Woods compared the dental arch with facial width. In 1953 Scott reported on individual variation in facial growth.

In none of the literature was the author able to find any definitive study showing the amount the intermolar and intercuspid distances changed during orthodontic treatment, orthodontic retention, and thereafter. Accordingly the following study was undertaken to obtain such information. Then Walter, 1951, presented a report on this very same subject. It was decided, nevertheless, to continue as planned and to present the findings in a different manner.

PROCEDURE

From the files of the orthodontic department of the University of Minnesota the first thirty-one records containing models before orthodontic treatment, at the completion of orthodontic treatment, and one or more years after termination of retention were used for this study. The beaks of a Boley micrometer were filed to a knife edge at the measuring surfaces. Using this micrometer measurements in tenths of millimeters were made of intermolar and intercuspid distances between the central fossae of the molars and the center of the tips of the cuspids. These measurements were made on the plaster models and recorded on a separate sheet for each patient. This record sheet contained spaces for the measurements of the models before orthodontic treat-

Read before the Mid-Western component of the Angle Society, January, 1960.

ment, at the completion of orthodontic treatment, and one or more years following removal of retention. Some patients had models at the end of retention so measurements were also made on these as an additional unplanned study. A record card for each patient was made on which were recorded in tenths of millimeters the differences between the above measurements. These differences, plus and minus, were used in the succeeding charts.

Presentation of the results in a readily understandable form became one of the more difficult tasks of the study. Charts, such as Walter used, present the measurements in the most accurate and composite manner, but are quite difficult to interpret. The method finally decided upon was to gather into single millimeter groups those patients with identical amounts of change, i.e., those between minus four tenths and plus five tenths of a digit were combined into the single group of that digit, and to chart these groups for each dimension studied.

Introduction to the Charts

It should be emphasized that this is not a quantitative study to determine how many patients' records behaved alike in each group. Rather, this is a qualitative study to determine just what amount of change occurred as shown by the groups.

Charts (a) and (b) Figure I show three more patients than those of Figure 2 because in one patient the upper dentition was treated and lower dentition was not, so the intermolar and intercuspid dimensions of the lower dentition were not included in the measurements, but the upper measurements were recorded, while the other two had models with broken molars. Hence Charts (a) and (b), Figure 1 show thirty-one measurements while those of Figure 2 show only twenty-eight measurements. Similarly in Charts (a) and (b), Figure 3, there are seventeen measurements of the upper intercuspid distance; in Figure 4 there are twenty-two measurements and both are less than the number in Figure 1 and Figure 2. This is because the intercuspid measurement was not recorded for those whose cuspids were not yet sufficiently erupted to permit the placement of orthodontic bands.

As mentioned previously, Charts (c) and (d) are included as an additional unintended study to demonstrate the changes which occurred during retention and the year or more following retention. Many patients did not have models at the end of retention, and so the number of records is less than in Charts (a) and (b). In Figures 3 and 4 Charts (d) show more records than Charts (c) because by the time of retention many of the previously not fully erupted cuspids had completed their eruption and so could be measured. This in no way invalidates the study, but emphasizes the accuracy of the method since no questionable measurements were recorded.

Changes Between The Upper Permanent Molars

Figure 1, Chart (a) presents the distance changes between the upper permanent first molars which occurred during the time interval from four up to as many as ten years, i.e., between the start of orthodontic treatment and the one or more years following removal of all retention appliances, which is called the ultimate measurement. The variation between groups of patients is striking: one patient's intermolar distance decreased four millimeters, two patients' intermolar distances increased five millimeters, and six patients presented no change whatsoever in their intermolar distance.

The question then arises as to how

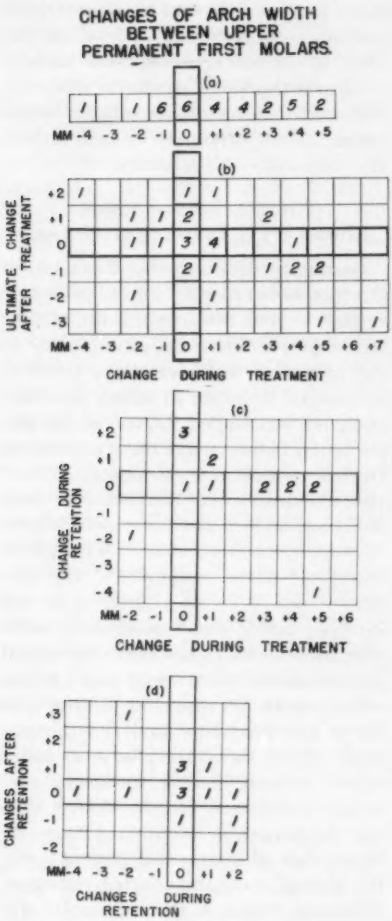


Fig. 1

much of this change may be the result of orthodontic treatment. *Figure 1, Chart (b)* shows in the vertical columns the changes which occurred in these same patients during their periods of orthodontic treatment, in the horizontal columns the changes which occurred between the end of treatment and one or more years following the period of retention (the ultimate). In the upper left quadrant is one patient whose intermolar distance decreased four millimeters during treatment, yet increased two millimeters after treatment (+2, −4), thus the resultant change is a decrease of only two millimeters and is recorded in the minus two-millimeter box in Chart (a). In the lower left quadrant Chart (b) is a patient, (−2 −2), whose intermolar distance decreased two millimeters during treatment and continued to decrease another two millimeters following treatment, the resultant total decrease is four millimeters which is registered in the minus four millimeter box in Chart (a). Similarly in Chart (b) in the extreme lower right quadrant is a patient (−3, +7), whose intermolar distance increased seven millimeters during treatment but decreased three millimeters following treatment thus producing a resultant increase of four millimeters. This patient is registered with four others in the plus four millimeter box in Chart (a). In the upper right quadrant of Chart (b) are two patients, (+1 +3), whose intermolar distances increased three millimeters during treatment and continued to increase an additional one millimeter following treatment, thus producing a resultant increase of four millimeters; these patients are registered with three other patients in the plus four millimeter box in Chart (a). Three patients presented no change in intermolar distance during or following treatment and are registered in the zero intersection of the horizontal and vertical columns of Chart (b) and in the zero box along with three other patients in Chart (a). Thus in some patients the change may be due to orthodontic treatment, since no change occurred after orthodontic treatment; in other patients changes did occur following orthodontic treatment which totally or partially eliminate the change during treatment, others continued in the same direction

as that which occurred during treatment.

From the records presented in the preceding charts it seems that the distance between the upper permanent molars will remain the same as at the end of the period of treatment only in those patients in whom the attained position is in harmony with all of the other forces acting upon those molars.

Thus orthodontic treatment does not determine the ultimate upper intermolar width; other forces and factors also influence this distance.

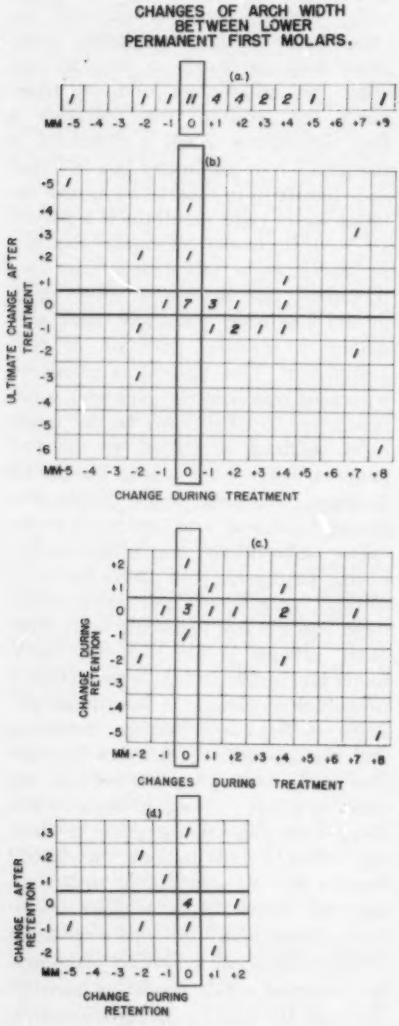


Fig. 2

Change Between the Lower First Permanent Molars

Generally speaking the distance changes between the lower molars is similar to that between the upper molars. *Figure 2 Chart (a),* the patient in the plus nine millimeter box presents the special situation in which one lower molar was tipped lingual to the upper molar before orthodontic treatment. During orthodontic treatment, Chart (b), the intermolar distance increased seven millimeters and ultimately following treatment this distance increased an additional three millimeters; this patient, (+3 +7), is registered in the extreme upper right quadrant (seven plus three is ten); however, the actual measurements are 6.7 mm plus 2.6 mm which equals 9.3 mm thus putting it in the 9 mm box. In Chart (c) this patient, (0, 7), shows the plus seven millimeter increase during treatment previously mentioned and no change during the period of retention. Chart (d) shows that although this patient (+3, 0), showed no change during retention, following retention the intermolar distance increased three millimeters. It should be mentioned here that in this same patient, simultaneously with the lower, the upper intermolar distance increased three millimeters during treatment, decreased two millimeters during retention, and then increased three millimeters following retention.

The changes in the lower intermolar distances are similar to those of the upper intermolar distances, *Figure 2, Chart (b).* There are two possible exceptions: one in the extreme lower

right quadrant and the other in the extreme upper left quadrant. The patient in the lower right quadrant (−6, +8) had no crossbite and no bicuspids extracted. The distance between the lower molars increased eight millimeters during treatment as seen in Chart (c), decreased five millimeters during retention, and Chart (d) decreased an additional one millimeter following retention. Minus five millimeters and minus one equal minus six millimeters the ultimate change shown in Chart (b). Thus the increase recorded in Chart (a) minus six plus eight millimeters is only plus two millimeters. The other patient, in the extreme upper left quadrant, (+5, −5) Chart (b), had four bicuspids extracted. The lower intermolar distance decreased five millimeters during treatment, but increased the five millimeters following treatment, so is recorded in the zero box in Chart (a). Unfortunately this patient had no model to show the lower molar width during retention. It is evident that strong forces determine the lower intermolar distance, and if these forces do not change during the period of treatment, then they will restore the intermolar width to its original distance.

Finally it appears evident that, regardless of what change is or is not made in the upper and lower intermolar distances during the treatment period, the ultimate intermolar distance will be established according to the dictates of the balance of forces produced by the muscles, function, and growth of that particular individual.

Change Between the Upper Cuspids

Some of the patients whose intermolar changes have been recorded had cuspids not erupted fully, so those patients with unerupted or partially erupted cuspids are not included in

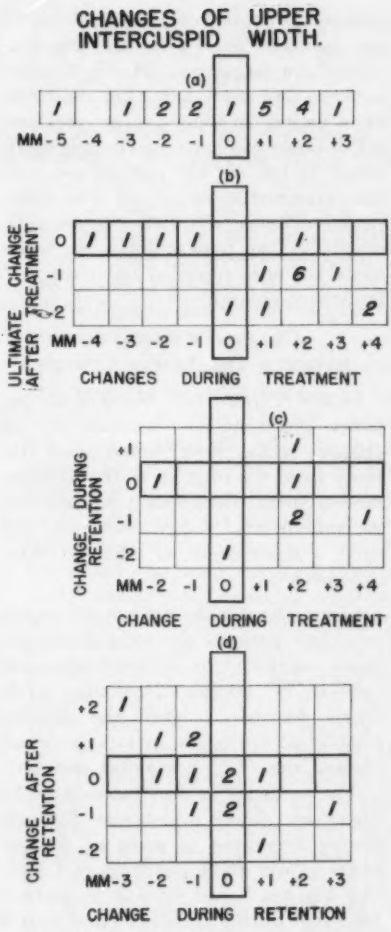

CHANGES OF UPPER INTERCUSPID WIDTH.
(a)
MM -5 -4 -3 -2 -1 0 +1 +2 +3
(b)
ULTIMATE CHANGE AFTER TREATMENT
MM -4 -3 -2 -1 0 +1 +2 +3 +4
CHANGES DURING TREATMENT
(c)
CHANGE DURING RETENTION
MM -2 -1 0 +1 +2 +3 +4
CHANGE DURING TREATMENT
(d)
CHANGE AFTER RETENTION
MM -3 -2 -1 0 +1 +2 +3
CHANGE DURING RETENTION

Fig. 3

Charts (a), (b), and (c). *Figure 3, Chart (a)* indicates that in only one patient did the distance between the upper cuspids not change ultimately from the original; all others either increased or decreased this distance.

Chart (b) shows that in each patient in which the intercuspid distance was increased or unchanged during the period of orthodontic treatment ("O" vertical column and to its right) this

distance ultimately decreased except for one patient (0, +2) who stayed as treated; in no patient did this distance increase ultimately following the treatment period. In those patients in whom the distance was decreased during treatment (to left of "O" vertical column) this remained as decreased. The intercuspid distance did not increase ultimately in any patient following treatment, i.e., none recorded above the "O" horizontal column.

Change of Distance Between the Lower Cuspids

Figure 4, Chart (a). Many of the patients presented an increase or no change in the lower intercuspid distance from the original to the ultimate measurement; the greatest increase was six millimeters. A few, however, did show a decrease to as much as three millimeters.

Chart (b). Unlike the upper cuspids, in a few patients the intercuspid distance continued to increase ultimately (above "O" horizontal column) while others decreased slightly the distance established during the treatment period (below the "O" horizontal column).

The tendency in the treatment of the upper and lower intercuspid distances during treatment of some of the patients (lower right quadrant of Charts (b) Figures 3 and 4) was to make it too great during treatment and thus it decreased after treatment; none of the patients show the intercuspid distance decreased sufficiently during treatment to cause it to be increased following treatment (upper left quadrant). Nevertheless it must be borne in mind that Charts (a), Figures 3 and 4, show that most of the upper and lower cuspid distances do change from their original measurements.

Thus, like the upper and lower intermolar distances, the ultimate cuspid position or intercuspid distance is the result not necessarily of orthodontic treatment but of the balance of other forces produced by the musculature, function, and growth of each particular patient. If orthodontic treatment did produce a permanent change in any

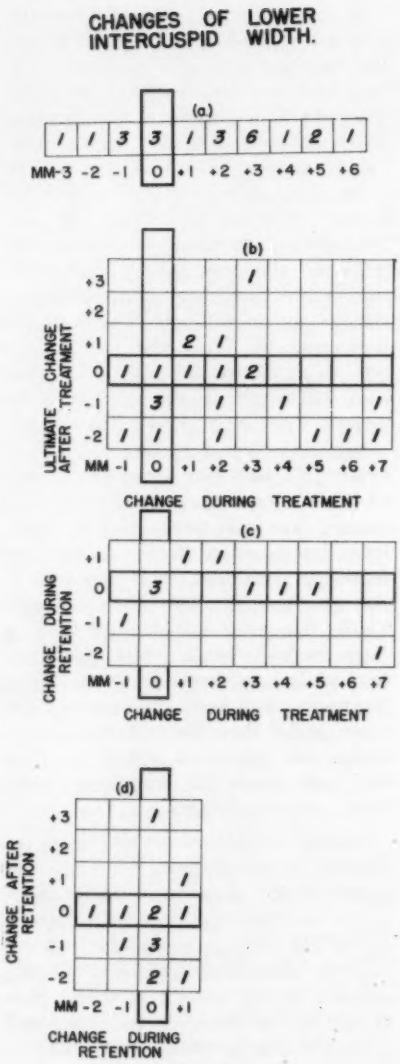


Fig. 4

of these forces, the resulting ultimate tooth position would be nearer to that at the end of treatment.

Changes During the Retention Period

Some of the patients, but not all, had models made at the end of the retention period. These being available, the question arose as to what changes occurred during retention and thereafter; these are presented in Charts (c) and (d), even though the number of patients is consequently smaller. In Figure 1, Chart (c) the vertical columns show the changes during treatment and the horizontal columns the changes during retention, while in Chart (d) the vertical columns show the changes during retention and the horizontal columns the changes following retention. About half of the patients' upper intermolar distances stayed as treated ("O" horizontal column, Chart (c)) while the remainder either increased and decreased during retention the changes made during treatment (above or below the "O" horizontal column). In the lower right quadrant is one patient (−4, +5) whose intermolar distance increased five millimeters during treatment and then decreased four millimeters during retention. Thus it may be that retention of the distance between the upper molars was ineffective. Yet two other patients (−0, +5) had the intermolar distance increased five millimeters during treatment and it remained that way during retention. In four patients no change was made to the intermolar distance during treatment ("O" vertical column); one remained unchanged (0,0) and three increased the distance two millimeters during retention (+2, 0).

In Figure 1, Chart (d) about half of the patients showed no change following the period of retention ("O" horizontal column) while the remainder present either an increase or a decrease (above or below the "O" horizontal column) of the intermolar distance following retention.

Thus treatment and retention do not determine the ultimate upper intermolar distance in many patients.

In Figure 2, Charts (c) and (d), the changes in the intermolar distance of the lower molars are presented for the period of retention and thereafter. These changes are similar to those for the upper molars.

In Figure 3, Chart (c), there are but few patients recorded because of unerupted or partially erupted cuspids, but these present all types of change during retention. Following retention, Chart (d), the only patients that showed an increase in the upper intercuspid distance were those in whom this distance was decreased (upper left quadrant) during the period of retention; it is interesting that the increase is not greater than the decrease which occurred during retention. The remaining patients had no change ("O" horizontal column) or had a decrease in the intercuspid distance (below the "O" horizontal column) following retention. Thus the upper retainer seems to have had little if any effect upon these patients in maintaining the upper intercuspid distance.

Figure 4, Chart (c). During the retention period in all except one patient (−2, +7), the intercuspid distance remained within plus or minus one millimeter of that established during the treatment period ("O" horizontal column). This would seem to indicate that the fixed lower cuspid-to-cuspid retainer is effective.

Chart (d). Removal of the cuspid-to-cuspid retainer permitted the cuspids to move as desired, and some did change their intercuspid distances within a range from plus three millimeters to minus two millimeters. Thus, even

though the cuspid-to-cuspid retainer is effective in maintaining the lower intercuspid distance, if this distance is not in balance with all of the other forces acting upon these lower cuspids, the cuspid will move to make this distance be in balance with such forces, regardless of the retention period.

The Effect of Bicuspid Extractions Upon Intermolar and Intercuspid Distances

The patients of this study were then divided into those who had bicuspids extracted and those who had not.

All of those patients who had bicuspids extracted showed a decrease from the original distance in the upper intermolar width ultimately (Figure 5). Only three patients without extractions showed a decrease while all of the others without extractions either remained unchanged or increased this distance ultimately.

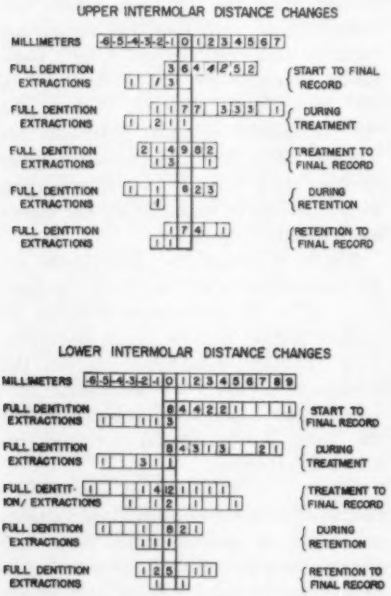


Fig. 5

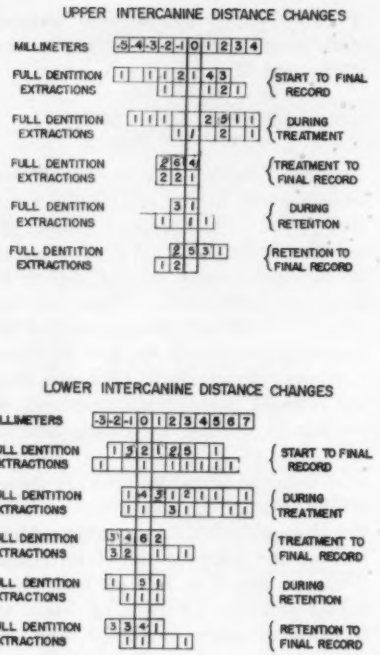


Fig. 6

The lower intermolar width changes (Figure 5) were similar to those of the upper except for three extraction patients who showed no change of intermolar width from before treatment to the ultimate model.

As to changes in the upper and lower intercuspid distances (Figure 6), those patients with extraction of bicuspids presented no discernible distinctive differences from the patients who had had no bicuspids extracted.

Thus extraction of bicuspids tends to decrease the upper and lower intermolar distances of the patients, but produces no discernible distinctive difference in the upper and lower intercuspid distances.

Conclusion

Orthodontic movement and retention of teeth produce lasting changes only

in those particular patients whose forces, including the anterior component of force, acting upon the teeth have changed in such a manner during treatment (and retention) as to support those particular teeth in the newly acquired positions. The changes of these forces acting upon the teeth may be growth and development of bony, muscular, and nervous tissues, combined with newly-acquired functional and emotional habits. Orthodontic movement of teeth per se does not establish any tooth in its new position ultimately.

Application to Orthodontic Treatment

If the intermolar or intercuspid distances are made too great during treatment then the distances will decrease and this will cause crowding of the teeth. This crowding can be eliminated by keeping the intermolar and intercuspid distances to a minimum during the treatment.

While mechanics is of the utmost importance for controlled orthodontic tooth movement, the most important problems yet to be solved are (1) how to teach the patient to function in all ranges of motion, (2) how to teach the patient to overcome nervous or other emotional habits which produce his malocclusion, (3) how to better predetermine the amount, kind, direction, and time of growth yet to occur.

Acknowledgements

The author is most grateful to Dean Theodore C. Blegen and the Graduate School of the University of Minnesota for the research grant which furnished funds to finance the assistance so readily given by the statistical department and the dental school photographic department. Dr. Allan Treolar was most helpful in developing the method used for presenting the findings; Mrs. A. Chaudhry prepared the charts shown in the illustrations plus many more not shown, and Mr. James Rothenberger supervised the assembly and photography of the charts.

Bibliography

Broadbent, B. Holly, 1937 The Face of the Normal Child, *Angle Ortho.*, 7:209-232.

Brodie, A. G., 1948 Growth of the Jaws and the Eruption of Teeth, *Oral Surg., Oral Med., & Oral Path.* 1:334-341.

Cohen, J. T., 1940 Growth and Development of Dental Arches in Children, *J. Am. Dent. Assoc.* 27:1250-1260.

Fox, J., 1814 Natural History of the Human Teeth, London, 2nd Ed.

Hunter, John, 1771 The Natural History of the Human Teeth, J. Johnson, London.

— 1839 Treatise on the Natural History and Disease of the Human Teeth, Haswell, Barrington, and Haswell, Philadelphia.

Lewis & Lehman, 1929 Observation of the Growth Changes of the Teeth and Dental Arches, *Dent. Cos.* 71:480-499.

Scott, James H., 1953 Individual Variation in Facial Growth, *Jour. Brit. Dent. Assoc.* 94:27-31.

Tomes, Charles, 1891 Study of Growth of Jaws, *Tr. Odonto. Soc. Grt. Brit.* 24: 143-158.

Wallace, J. S., 1911 A Note on Normal Development of the Jaws, Dent. Rec. 31: 216-217.

— 1927 Variations in the Form of the Jaws, New York: William Wood & Co.

Walter, D. C., 1953 Changes in the Form and Dimension of Dental Arches Resulting From Orthodontic Treatment, *Angle Ortho.* 23:1-18.

Woods, Guy A. Jr., 1950 Changes in Width Dimensions Between Certain Teeth and Facial Points During Human Growth, *Am. J. Ortho.* 36: 676-700.

Zsigmondy, Otto, 1891 The Alteration of the Dental Arch. *Brit. Dent. Sci.* 34: 214-215.

1201 Lowry Medical Arts Bldg.

A Comparative Study Of Cephalometric Superimposition

EARL O. BERGERSEN, D.D.S., M.S.D.
Winnetka, Illinois

INTRODUCTION

Little research is evident in the field of cephalometric superimposition. Perhaps the reason for this is due to the difficulty involved in objectively interpreting and comparing the various methods of orientation. Attempts to appraise one method to another have resulted in subjective conclusions[1,2,3] as no cranial area or landmark, necessary as a reference point, appears to remain constant in size and position during growth. Since most presently - used methods of orientation are of untested reliability, it seems that any results of studies dependent upon these methods are of questionable significance.

Broadbent[4,5] was probably the first to recognize the problems of interpreting cephalometric radiographs on a longitudinal basis. He noticed that the cranial base showed a relatively small amount of size increase with growth and, therefore, used this as a basis for orientation on registration point.

McDowell,[1] in evaluating different methods of orientation, thought that the most desirable method was that of using successive calvarial outlines as a means of reference. He employed lambda, bregma, and Bolton points to control the rotation of these outlines. McDowell felt that this method was superior to other methods because several reference points were used to orient the outlines. Since approximately 90% of calvarial growth is completed by six years of age, this method afforded a large minimal growing area as a reference base.

Brodie[6,7] made use of the sella to nasion line registered on sella as a method of orientation because it served as a division between the cranial vault and face, and provided a stable reference base against which sutural facial growth could take place. The use of sella turcica and nasion as reliable fixed reference points, however, has been criticized in recent studies. Baume[8] said that sella could not be considered a reliable reference point since its position is dependent on the active growth of the cranial base (spheno-occipital synchondrosis) and the investing pituitary gland. By using dried skull material, Scott[9] found that there was a superior migration of the landmark, nasion. The anterosuperior direction of the suture, as viewed from a sagittal section, tends to support this finding. Moore,[10] by using the vital staining technique on macaque monkeys, found the presence of stain on the nasal surface of the nasofrontal suture and interpreted it as growth in this particular area.

Another reference line, the cribriform plane, was introduced as a superior method of superimposition by De Coster.[11] This line is made up of the jugum sphenoidale, the cribriform plate, and the internal plate of the frontal bone and is credited to be of constant shape after seven years of age. Ford[12] substantiated this constancy on dried skull material.

The fact, however, that a particular area is unaltered in shape during growth does not totally substantiate its usefulness in superimpositioning. Any

Department of Orthodontics, Northwestern University Dental School.

alteration in position of an area, whether stability of shape is a characteristic or not, will reduce its accuracy in orientation. A strong possibility exists that a displacement of De Coster's cribriform plane may be the result of normal growth of the spheno-occipital synchondrosis.

Therefore, it is the purpose of this investigation to develop a method of superimposition which may be more accurately adapted to longitudinal cephalometric research. It will then be compared statistically to other presently-used methods to ascertain its relative accuracy.

Material

The lateral cephalometric radiographs used in this study were obtained from the records of the Bolton Study of the Development of the Face of the Growing Child, Department of Anatomy, School of Medicine, Western Reserve University, Cleveland, Ohio, through the courtesy of its director, Dr. B. Holly Broadbent. Tracings of longitudinal radiographs were made from forty subjects, twenty white females and twenty white males. The age distribution of this sample appears in Fig. 1.

The cases were selected on the basis of the following criteria:

1. Non-orthodontically treated.
2. No serious diseases which could affect growth.
3. No operations on the facial area with the exception of tonsil and adenoidectomies.
4. No fractures of the skull or other areas of the head.
5. All anterior permanent teeth present.
6. Natural posterior occlusion present.
7. No clefts of the lips or palate (soft or hard).
8. Clarity of radiographs.

Details concerning the sampling of the individuals of the Bolton Study are discussed by Simmons and Todd.[13] In general, they stated that the sample was primarily of North European ancestry, while willingness on the part of the parents to allow their children to take part in the study was the greatest criterion of selection.

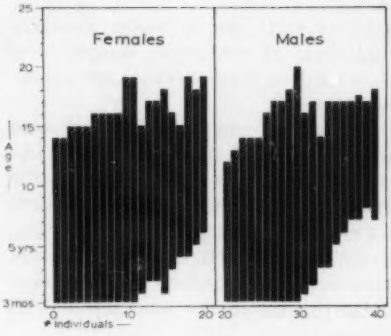


Fig. 1 Age distribution of sample.

Method

Lateral cephalometric radiographs were traced to include the structures indicated in Fig. 5. Each of the forty series of tracings was oriented according to the following technique. Each calvarial outline was centered so that an equivalent amount of growth enlargement could be seen anteriorly, superiorly, and posteriorly between each preceding tracing. The bony landmarks, nasion and anterior nasal spine, were maintained on absolute straight lines throughout each longitudinal series as each calvarial outline was centered concentrically around the previous tracing. The above orientation has been termed the intersection point method of superimposition (Fig. 7).

The two angles, nasion-intersection point-anterior nasal spine and intersection point-nasion-anterior nasal spine (Fig. 7) were measured for each orientation and repeated to obtain three trials for each of the forty series. Aver-

ages for each pair of angles for every individual of the entire sample were then used to permanently superimpose each series.

All angular measurements were read to the closest 0.5 degree, while the linear measurements were read to the closest 0.5 millimeter. Correctional scales for enlargement compensation, based on the midsagittal plane to film distance, were applied to all linear measurements to the accuracy of 0.25 millimeter.

In order to ascertain whether proportionality of growth movement of maxillary landmarks existed, the statistical analysis of variance[14,15] was applied to linear measurements of nasion and anterior nasal spine.

The reliability of the yearly measurements over that of an inclusive measurement for the whole age range of each individual in this study was established by statistical means. The coefficient of reliability between the individual annual measurements and one inclusive measurement was significant at the 1% level of confidence (r=0.983)*.

It was observed that during growth there was a tendency for the posterior extensions of incremental growth lines of maxillary landmarks to intersect at a common point. This tendency provided a basis of comparing other orientation methods with the method used in this study. The point of intersection of posterior extensions of the incremental growth lines of nasion and anterior nasal spine was located for the intersection point method of superimposition. It was also located similarly for the sella-nasion registered on sella method and the registration point method. For the latter two methods of superimposition, the earliest (not under two years of age) and latest tracings of each series were used to locate the necessary landmarks**. The age of each of these tracings varied between individuals, but not between the three techniques.

Since the location of the intersection of nasion and anterior nasal spine incremental lines is part of the intersection point method of orientation, it was not necessary to relocate it. The three intersection points were designated as I for the intersection point method, I (SN) for the sella-nasion registered on sella method, and I (R) for the registration point method.

The analysis of variance was used to determine differences between the three superimposition techniques. This analysis was calculated from the measurements of the proximity of extensions of incremental landmark lines to this intersection point. Three additional upper facial landmarks (rhinion, pronasale soft tissue, and point A) were located for each individual from the earliest and latest tracings, as before. Straight lines connecting the two points of each landmark were extended posteriorly (Fig. 2). The closest distance that each line came to the intersection point for each method of superimposition was measured. The results of the analysis of variance and tests of designed comparisons[14,15] appear in Table I.

Most landmarks, reference points, and lines used in this study are midline structures and are defined in terms of norma lateralis in the cephalometric radiographic film. Anterior nasal spine, ANS, posterior nasal spine, PNS, nasion, N, sella, S, Bolton point, Bo, and palatal line, ANS-PNS are familiar points and lines.

*The confidence level of "P" (probability) is less than 1%.

**Following two years of age, most of the subjects of the Bolton Study were fixed in the cephalostat in the routine manner. Prior to two years of age, however, the individuals were usually fixed in a reclining position. Therefore, this potential variation was eliminated.

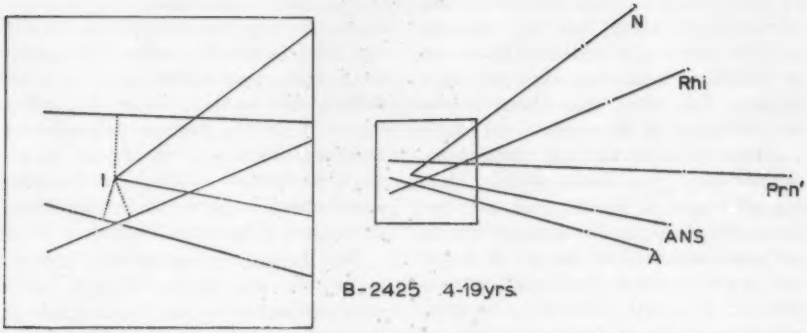


Fig. 2 Technique of obtaining measurements representing the proximity of extensions of incremental landmark lines to the intersection point, I. Left, Enlargement of measured distances from pronasale soft tissue (Prn'), rhinion (Rhi), and point A (A) to intersection point (I). Right, Straight lines connecting earliest and latest landmarks with posterior extensions. The intersection of extensions of nasion (N) and anterior nasal spine (ANS) demarcates the intersection point (I).

Other points and lines are:

Intersection point, I. The intersection of the posterior extensions of the incremental growth paths of landmarks nasion and anterior nasal spine when they are maintained on straight lines, as the calvarial outlines are concentrically centered upon one another.

Intersection point by sella-nasion method, I(S-N). The intersection of the posterior extensions of the lines joining the earliest (not under two years of age) and latest landmarks of nasion and anterior nasal spine in a series superimposed on sella-nasion registered on sella method.

Intersection point by registration method, I(R). The intersection of the posterior extensions of the same lines in a series superimposed on registration point method.

Rhinion, Rhi. The most inferior point on the internasal suture.

Pronasale soft tissue, Prn'. The most anterior tip of the nose as defined by a tangent, which is perpendicular to the palatal line (ANS-PNS).

Point A. The most posterior point on the inner curvature of the maxillary alveolar process. When a tangent is drawn perpendicular to the palatal line (ANS-PNS) to contact the most posterior point on the inner curvature of the maxillary alveolar process, this point delineates Point A.

Calvarial outline. The midline outline of the external surface of the frontal, parietal, and occipital bones.

Incremental growth line. A straight line joining a longitudinal series of points representing the same landmark as it progresses during growth.

Discussion and Findings

The Problems Involved in Superimposition.

There are two general purposes of superimposing tracings of lateral radiographic cephalograms. One is for analyzing local changes within a very limited area. The other is for analyzing more generalized regions or relations between different areas. Both purposes have one common problem in that it is difficult to locate any particular point or area that is without modification in shape due to growth and development.

In the generalized type of orientation, where large areas are of concern, another problem is evident. This is one of shifting relations between different regions. For ideal generalized superimpositioning, it is necessary to locate a reference point void of changes not only in shape, but also in position, during all stages of growth and development. For example, the crowns of teeth are essentially void of changes in shape, but not of position, during the growth process. It would, therefore, be inaccurate to orient cephalometric tracings on the successive outlines of one central incisor and proceed to describe the progress of growth of other areas on this basis.

The fact that different areas grow at different rates, which are not proportional, indicates that a perfectly accurate method of orientation will never be found which satisfies all areas at all stages of growth. Many investigators have found that the cranial vault is more rapid in growth than the face at early ages. Incremental growth graphs and statistical findings show that the rates vary and that they are not proportional.[16] Preceding two years of age, the cranial vault increases in size at a more rapid rate than the facial structures, while, at a later stage, the situation is reversed. The shifting rates of growth between the two areas would produce error in one, if the other were used as a basis of orientation. Therefore, when the cranial vault is of primary interest, an orientation technique within this area is indicated. However, if the primary concern is within the facial area, an orientation, which utilizes the cranial vault, introduces error into any findings resulting from this method.

The problem in superimposition is to find a center or axis of movement from which all growing areas are radiating or moving. If certain areas, such as the cranial base, remain unaltered in shape during growth, they are not necessarily well adapted to orientation. The possibility exists that entire areas may be shifting due to the growth of another region. Since no perfect technique of superimposition can satisfy all areas, the best method would be one which would most ideally orient certain cranial regions of primary interest.

The accuracy of orientation, according to the sella-nasion method (with sella registered), seems questionable in that sella is part of a rapidly growing region. For sella to remain in a stable position while the growth at the sphenoccipital synchondrosis is dissipated in a downward and backward direction is unlikely. The possibility of nasion moving along a straight line arbitrarily drawn from sella to nasion is also unlikely.

Tracings of calvarial and facial outlines in a longitudinal series can be superimposed without having these outlines intersect. Therefore, it is suspected that errors exist when such intersections occur in some of the common methods of superimposition (Figs. 4, 5, and 6). A method of orientation is needed which eliminates intersections of calvarial and facial outlines of progressive tracings. It should also minimize error by satisfying the superimposition requirements of different areas or of any particular area.

The Hypothesis of Straight Line Landmark Movement During Growth.

Brodie[6] observed that individual landmarks tended to progress on relatively straight lines in serial cephalometry. The implication of this statement is that growth or movement of different landmarks occurs proportionally, but not necessarily at the same rate or in the same direction. In order to have two or more landmarks progress on straight lines, the growth rates must be proportional so that fluctua-

tions in one will produce proportional fluctuations in the other landmarks. It is evident that similar factors must be operating to produce this proportionality, otherwise, curved lines of landmark progression would result.

The intersection point method of orientation is partially dependent on the principle that certain landmarks progress on straight lines during growth. To statistically analyze the validity of this principle, the analysis of variance was used. This analysis was applied to show the interaction between the landmarks and the incremental movement during specific intervals of time. This interaction between the landmarks nasion and anterior nasal spine and the millimetric increments measuring the movement of landmarks during a definite time interval, when insignificant ("F" ratio less than 1.0), would support the hypothesis that different landmarks grow proportionally.

The results indicated that landmarks do not grow proportionally when measured at yearly intervals. This evidence would indicate that straight line progression of facial landmarks is doubtful. However, when two-year increments were used, the landmarks nasion and anterior nasal spine showed proportional movement, evidenced by insignificant "F" ratios (0.841, 0.173, and 0.466) of interactions between the landmarks and increments in three age groups (2-10 years in 17 cases; 6-16 years in 19 cases; and 10-16 years in 11 cases).* The differences in the results between annual and two year increments could be due to a one year growth lag of one landmark over another, to slight rotations of the series during orientation, or to the inherent error below the limits of measuring accuracy.

Statistical Comparisons of the Three Methods of Superimposition.

The tendency for incremental paths of maxillary landmarks to radiate from a common center indicates that a center of growth movement might exist for the maxillary area. When such a center of growth movement is used as a means of orientation (e.g. intersection point method) certain desirable results seem to be produced. In this technique a greater tendency for facial landmarks to progress on symmetrically radiating lines over that of other techniques was noted. There also seemed to be fewer areas of cranial outline intersections,

*Additional statistical data is available at the Northwestern University Dental School Library, Chicago, Illinois.

TABLE I

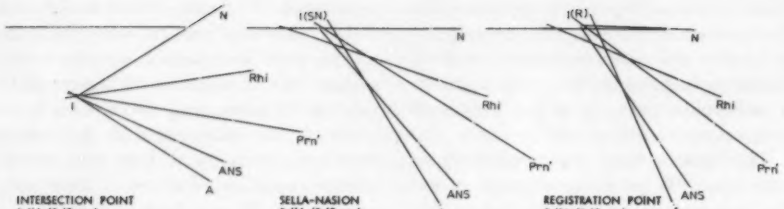
SUMMARY OF ANALYSIS OF VARIANCE OF THREE METHODS OF SUPERIMPOSITION

SOURCE	DEGREE OF FREEDOM	MEAN SQUARE	"F" RATIO	DIVISOR
Methods†	2	67.1543	20.470**	M/SM††
Sella-nasion x registration pt.	1	0.2638	0.080	S-NxR/SM
Intersection pt. x sella-nasion & registration pt.	1	134.0449	40.858**	IxS-N&R/SM

†Sella-nasion x registration pt. x intersection pt.

††Divisor (SM) represents Subjects x Methods.

**The confidence level of "P" (probability) is less than ½%.



INTERSECTION POINT
B-114 (5-18 yrs.)

SELLA-NASION
B-114 (5-18 yrs.)

REGISTRATION POINT
B-114 (5-18 yrs.)

INTERSECTION POINT
B-1921 (2-16 yrs.)

SELLA-NASION
B-1921 (2-16 yrs.)

REGISTRATION POINT
B-1921 (2-16 yrs.)

INTERSECTION POINT
B-1908 (2-17 yrs.)

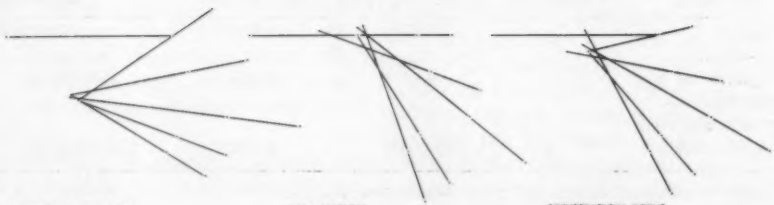
SELLA-NASION
B-1908 (2-17 yrs.)

REGISTRATION POINT
B-1908 (2-17 yrs.)

INTERSECTION POINT
B-1156 (5-18 yrs.)

SELLA-NASION
B-1156 (5-18 yrs)

REGISTRATION POINT
B-1156 (5-18 yrs.)



INTERSECTION POINT
B-3047 (3-19 yrs.)

SELLA-NASION
B-3047 (3-19 yrs.)

REGISTRATION POINT
B-3047 (3-19 yrs.)

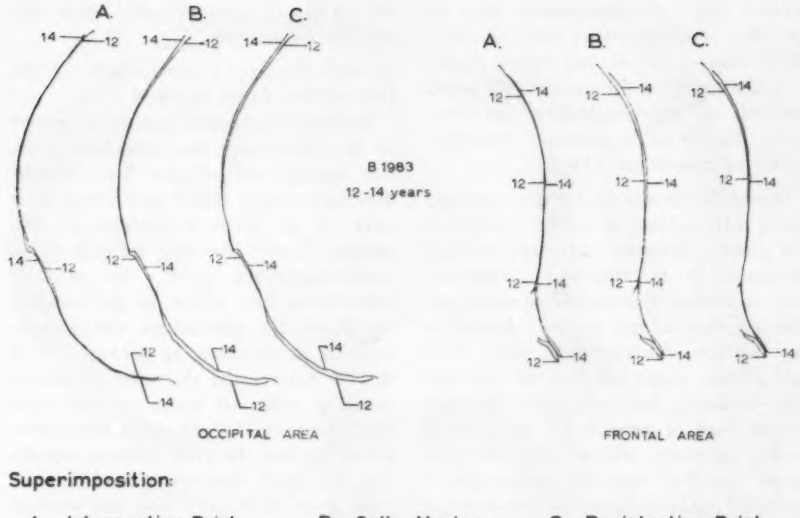


Fig. 4 Illustration of typical calvarial outline intersections. A, represents superimposition by the intersection point method showing lack of intersections. B, represents superimposition by the sella-nasion registered on sella method showing occipital intersections. C, represents superimposition by the registration point method showing occipital intersections.

particularly in the nasal and occipital areas.

The ability of facial landmarks to move symmetrically from one another during growth enabled a statistical comparison to be made between different methods of orientation. The posterior extensions of incremental lines representing the landmarks, rhinion, pronasale soft tissue, and point A facilitated the measuring of skewness about a common intersection point created by nasion and anterior nasal spine.

There is a significant difference (Table I) at the 0.5% level of confidence between all three methods of superimposition ("F" ratio=20.470**). When the sella-nasion and registration point methods were statistically compared (Table I), an insignificant difference resulted ("F" ratio=0.080). However, when the intersection point method was compared to the other two methods (sella-nasion and registration point) combined, a significant difference at the 0.5% level of confidence ("F" ratio = 40.858**) resulted. Statistical evidence, therefore, indicates that the intersection point method of orientation enables landmarks of the maxillary area to move apart from one

**The confidence level of "P" (probability) is less than ½%.

Fig. 3 Illustration of differences in proximity of posterior extensions of landmarks rhinion (Rhi), pronasale soft tissue (Prn'), and point A (A) to intersection point (I), formed by extensions of nasion (N) and anterior nasal spine (ANS) landmarks. Left, represents intersection point method of superimposition. Center, represents sella-nasion registered on sella method of superimposition. Right, represents registration point method of superimposition.

another more proportionately than in the other methods tested. Also, the posterior extensions of the upper facial area landmarks in the intersection point method of superimposition intersect more readily at a common point or center of movement (Fig. 3).

Generally, in any orientation method, fewer intersections of outlines occur as the growth between calvarial tracings increases. It is, therefore, relatively easy to obtain techniques of superimposition that do not produce intersecting outlines during early ages. The intersection point method of orientation, however, becomes more accurate as the rate of growth of the cranial vault decreases, which minimizes the space between successive tracings of calvarial outlines. Since the whole series can be rotated to the extent of these spaces, the correct position of orientation would be present within this leeway space.

Intersections of any calvarial or facial outlines were rarely seen when the intersection point method of orientation was used. Figure 4 illustrates the tendency for the sella-nasion and registration point methods of superimposition to have intersections of cranial outlines in the occipital area. This is particularly apparent at ages when the cranial vault is close to completion of its growth. These intersections are probably due to a clockwise rotation of the serial orientations. There is a possibility that the natural growth directions of nasion and sella are being restrained by the sella-nasion and registration point methods of orientation, which would create this rotation. This rotation also produces intersections of the external nasal and lip outlines (Figs. 5 and 6). The intersection point method of orientation (Fig. 7) illustrates the anterosuperior growth of nasion, which allows the nose to move predominantly forward. The questionable intersections in the nasal, lip, and occipital areas are thereby eliminated.

Growth Findings Characteristic of the Intersection Point Method.

Without exception, nasion migrated in an anterosuperior direction from the original sella-nasion line. Nasion also had greater linear movement than sella in all forty individuals of the sample. In only one case did sella move posterosuperiorly from the original sella-nasion line, while, in the remaining cases, the movement was anterosuperior in direction. In general (37 of the 40 cases), the direction of movement of sella was more vertical than that of nasion. Of the remaining three cases, one had the same vertical angulation for both landmarks and, in the other two cases, sella had less vertical angulation than nasion. Due to the greater linear movement of nasion, the angular comparison of the earliest to latest sella-nasion lines exhibited an opening of the angle in the anterior direction. The above findings which concern the behavior of sella and nasion, although dependent on the method of orientation, are in agreement with the findings of Baume,[8] Scott,[9] and Moore.[10]

In 90% of the sample (36 of 40 individuals), the palatal line, during growth, descended at the posterior nasal spine more rapidly than at the anterior nasal spine. Only 2.5% of the individuals exhibited a parallel descent of the palate (palatal line). These findings are in contrast to those of Brodie's,[7] which were based on a sample of 19 individuals using the sella-nasion method of orientation. In his study, 52.6% of the sample showed a parallel descent of the palate; 42.1% descended at a greater rate in the anterior region of the palatal line, while 5.3% descended at a greater rate in the region of the posterior nasal spine.

The present study (40 individuals)

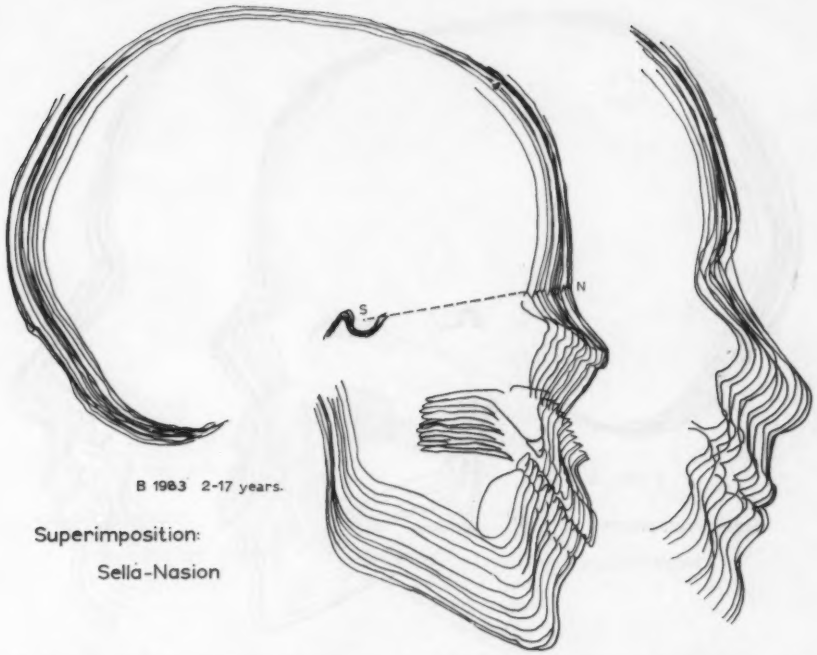


Fig. 5 Serial orientation of an individual by the sella-nasion registered on sella method of superimposition. Note the external nasal and lip outline intersections.

was oriented on the sella-nasion line as a means of comparison to Brodie's study. The following differences resulted. Ten per cent of the cases in the author's sample descended in a parallel manner; 50% had more descent in the anterior region, and 40% had a greater descent in the posterior region of the palatal line. Therefore, the present study indicates that, regardless of the method of superimposition, the palate descends, during growth, at a greater rate in the area of the posterior nasal spine than has been previously believed. This finding is particularly evident (90% of individuals) when cases are oriented according to the intersection point method.

In the intersection point method of superimposition, sella, irrespective of the position of the intersection point (I), moved anterosuperiorly in a somewhat parallel fashion to the long axis of the posterior cranial base. This finding is consistent with presently accepted theories concerning the direction of growth of the spheno-occipital synchondrosis and its influence on the anterosuperior migration of the basisphenoid, including the structure of sella turcica.

The comparative movements of facial landmarks between the three methods of superimposition are illustrated in Figure 8. All facial landmarks, when oriented by the sella-nasion and registration point methods, were rotated in an inferior (clockwise) direction from the same landmarks when oriented by the intersection point method. In comparing the landmark behavior of the

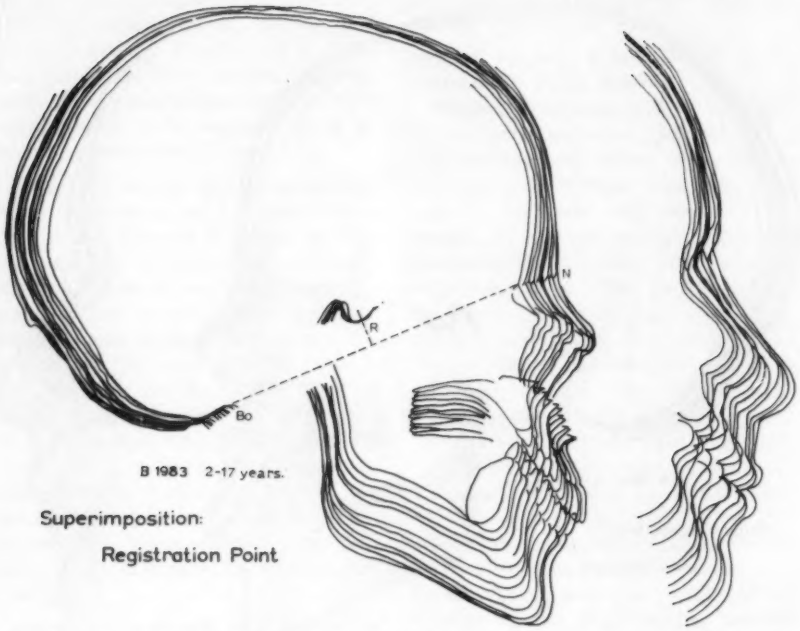


Fig. 6 Serial orientation of an individual by the registration point method of superimposition. Note the external nasal and lip outline intersections.

TABLE II

THE DIRECTIONAL BEHAVIOR OF LANDMARKS NASION (N) AND ANTERIOR NASAL SPINE (ANS) ORIENTED ON SELLA-NASION COMPARED TO THE SAME LANDMARKS OF THE REGISTRATION POINT METHOD

	Inferior to N (of reg. pt.)	Superior to N (of reg. pt.)	Same as N (of reg. pt.)	Size of Sample
N (of sella-nasion)	29 (72.5%)	7 (17.5%)	4 (10 %)	40
	Inferior to ANS (of reg. pt.)	**Superior to ANS (of reg. pt.)**	**Same as ANS (of reg. pt.)**	**Size of Sample**
ANS (of sella-nasion)	14 (35 %)	21 (52.5%)	5 (12.5%)	40
	Inf. to N & ANS (of reg. pt.)	**Sup. to N & ANS (of reg. pt.)**	**Inf. to N Sup. to ANS (of reg. pt.)**	**Inf. to N Same as ANS (of reg. pt.)**	**Same as N Sup. to ANS (of reg. pt.)**
N & ANS (of sella-nasion	14 (35 %)	7 (17.5%)	10 (25 %)	5 (12.5%)	4 (10 %)

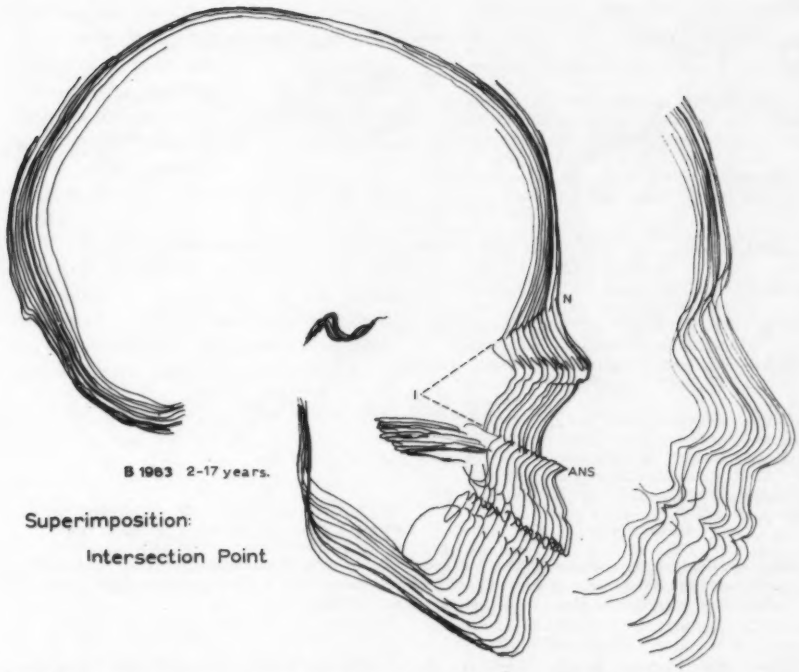


Fig. 7 Serial orientation of an individual by the intersection point method of superimposition. Note the lack of external nasal and lip outline intersections.

sella-nasion to the registration point methods (Table II), the landmarks of the sella-nasion technique were rotated clockwise in 35% of the cases and counterclockwise in 17.5% from those of the registration point technique. Of the remaining 47.5% of the sample, the displacement of landmarks in varying directions complicated the determination of rotations. From these findings, it is evident that, in the sella-nasion and registration point methods, there is no consistent relation of one orientation method to the other. The statistically insignificant differences between the two methods, previously discussed, substantiates this finding.

Summary and Conclusions

Few investigations have been devoted to cephalometric superimposition and these have generally been subjective in nature. Since a large portion of the results of research in growth and development has been based on particular methods of orientation, it is important that the reliability of these methods be established. The validity of some of the present methods of superimposition has been questioned by many investigators. It has been the purpose of this study to develop a method of orientation which might be more accurately adapted to longitudinal cephalometric research and to compare it statistically to other presently-used methods.

The headplates of forty individuals, whose ages ranged from three months to twenty years, were studied longitudinally. These records were obtained

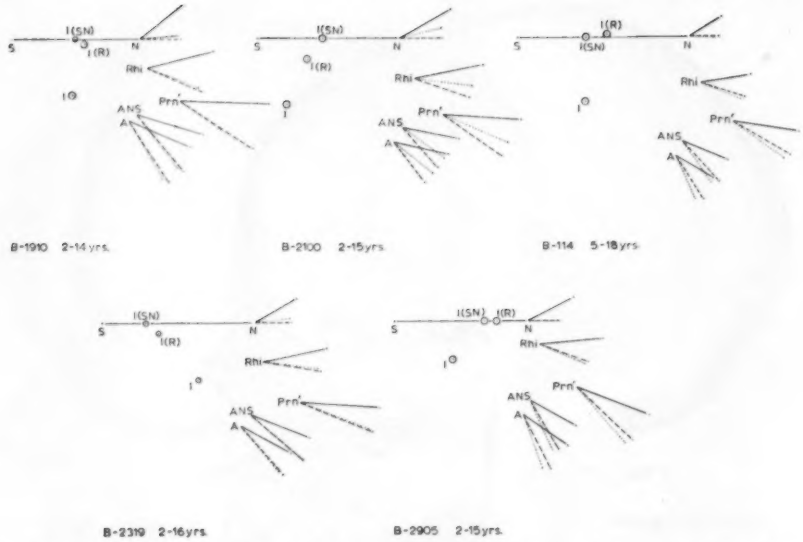


Fig. 8 Illustration comparing the difference in growth directions of facial landmarks by three methods of superimposition: Solid line, intersection point method; dash line, sella-nasion method; dotted line, registration point method.

from the Bolton Study through the courtesy of Dr. B. Holly Broadbent. The cephalometric tracings were serially oriented by maintaining the landmarks nasion and anterior nasal spine on straight lines while centering all calvarial outlines concentrically. This intersection point method of orientation was then compared statistically to the sella-nasion (registered on sella) and registration point methods of superimposition.

As a result of this investigation, the following conclusions can be made:

1. There is a significant difference (at the 0.5% level of confidence) between the intersection point, sella-nasion, and registration point methods of superimposition. There is, however, no significant difference between the sella-nasion and registration point methods, while there is a significant difference (at the 0.5% level of confidence) between the intersection point method and the latter two methods collectively.

2. Statistical evidence indicated that, during growth, facial landmarks emanate more accurately from a common center of movement and migrate apart from each other more proportionately in the intersection point method than in the other two methods.

3. There were very few cranial and facial intersections in the intersection point method of orientation. The other two techniques had many intersections, primarily in the occipital, nasal, and lip outline regions.

4. Nasion, in all forty individuals, oriented by the intersection point method possessed greater linear movement in an anterosuperior direction than did sella. Sella had a greater vertical angulation to the original sella-nasion line than did nasion in 92.5% of the individuals during growth. Sella also moved anterosuperiorly from the original sella-nasion line in all individuals except

one, which moved posterosuperiorly.

5. Only 2.5% of the sample illustrated a parallel descent of the palatal line during growth, while 90% descended more at the posterior than at the anterior nasal spine. A greater anterior than posterior descent of the palatal line occurred in 7.5% of the cases.

6. In the sella-nasion and registration point methods of orientation, the directions of movement of all facial landmarks studied were more inferior to the directions present in the intersection point method of orientation.

999 *Linden Ave.*

REFERENCES

1. McDowell, R. M.: The Use of Lateral Head Radiographs for Evaluating Orthodontic Results as Distinguished from Growth Changes, *Am. J. Ortho. & Oral Surg.* 27: 59-74, 1941.
2. Nelson, T. O.: A Study of Facial Growth Utilizing Elements of the Cranial Base for Registration, M.S.D. thesis, *University of Washington*, Seattle, Washington, 1959.
3. Elmajian, K. E.: A Serial Study of Facial Growth as Related to Cranial Base Morphology, M.S.D. thesis, *University of Washington*, Seattle, Washington, 1959.
4. Broadbent, B. H.: A New X-Ray Technique and Its Application to Orthodontia, *Angle Ortho.* 1: 45-66, 1931.
5. Broadbent, B. H.: The Face of the Normal Child, *Angle Ortho.* 7: 183-208, 1937.
6. Brodie, A. G.: On the Growth Pattern of the Human Head from the Third Month to the Eighth Year of Life, *Am. J. Anat.* 68: 209-262, 1941.
7. Brodie, A. G.: Late Growth Changes in the Human Face, *Angle Ortho.* 23: 147-157, 1953.
8. Baume, L. J.: A Biologist Looks at Sella Point, *Tr. European Orthodont. Soc.*, pp. 150-159, 1957.
9. Scott, J. H.: Growth at Facial Sutures *Am. J. Ortho.* 42: 381-387, 1956.
10. Moore, A. W.: Head Growth of the Macaque Monkey as Revealed by Vital Staining, Embedding, and Undecalcified Sectioning, *Am. J. Ortho.* 35: 654-671, 1949.
11. De Coster, L.: Une Nouvelle Ligne de Reference pour l'Analyse des Teleradiographies Sagittales en Orthodontie, *Rev. de Stomatologie* 52: 937-953, 1951.
12. Ford, E. H. R.: Growth of the Human Cranial Base, *Am. J. Ortho.* 44: 498-506, 1958.
13. Simmons, K., and Todd, T. W.: Growth of Well Children: Analysis of Stature and Weight, Three Months to Thirteen Years, *Growth* 2: 95-134, 1938.
14. Snedecor, G. W.: Statistical Methods, ed. 5, Ames, 1956, *Iowa State College Press.*
15. Harris, S. C.: Personal Communication.
16. Bergersen, E. O.: A Longitudinal Growth Analysis of the Human Facial Profile from Three Months to Fifteen Years of Age, M.S.D. thesis, *Northwestern University*, Chicago, Illinois, 1960.

The Relationship Between Eruption, Calcification, And Crowding Of Certain Mandibular Teeth

RICHARD ELDON BRADLEY, D.D.S., M.S.
Tulsa, Oklahoma

INTRODUCTION

This is a study of the mandibular permanent canine and premolars to investigate the timing of their eruption and calcification, and to determine whether this has any relation to crowding in the mandibular permanent dentition.

Mean ages of eruption have been reported by Cattell[1], Cohen[2], Klein, Palmer, and Kramer[3], Hurme[4], and many others. A difference between sexes was noted in mean eruption times, but no difference has been found between right and left sides of the dental arch. The sequence of eruption of different teeth was studied by Lo and Moyers[5], and Garn and Lewis[6].

The relation of age and dental calcification was investigated by Nolla[7], and eruption as related to dental calcification was reported by Carlson[8], and Shumaker and El Hadary[9].

MATERIAL

Radiographs and dental casts for a sample of eighty-nine boys, predominantly of mixed European stock of middle socio-economic background, were selected from the files of the Elementary School Growth Study at the University of Michigan on the basis of two criteria.

1. It was necessary that there be annual lateral jaw radiographs of the right side of the mandible. These were taken at yearly intervals plus or minus one month, usually during the month in which the birthday occurred. The age range was from three to eighteen years; there was an average of 6.9 annual radiographs in the series for each individual. The greatest number of series in progress at one time was 86 at age nine. The procedure used for taking the radiographs was standardized, but not cephalometric, and all were taken by Professor Albert G. Richards at the Radiographic Department of the University of Michigan School of Dentistry. The right side of the subject's face was held against the cassette with his nose about one-fourth inch from its surface. The tube was positioned so that the central ray passed below the body of the mandible on the left side and through the body of the mandible on the right side.

2. Also required was a dental cast with all mandibular permanent teeth erupted anterior to and including the first permanent molar. The mean age at which the casts were obtained was fourteen and the latest age was nineteen.

METHOD

From the radiographs two types of data were recorded for the mandibular right canine and premolars. (1) Dental calcification stages, as defined by Nol-

This investigation was carried out at the Department of Orthodontics, School of Dentistry, The University of Michigan, and was supported in part by Research Grant D-224 (C3) from N.I.D.R., U.S. Public Health Service

Statistical assistance was given by Professor Paul S. Dwyer, Professor of Mathematics and Consultant in the Statistical Laboratory of The University of Michigan

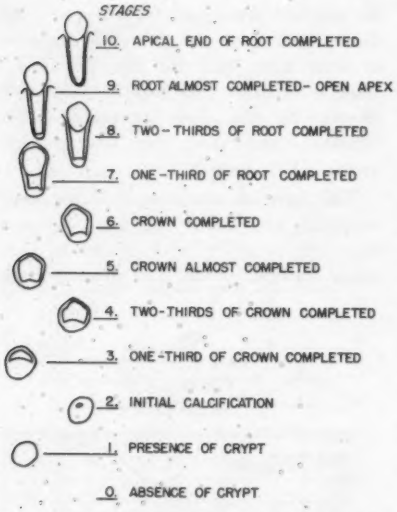

STAGES
10. APICAL END OF ROOT COMPLETED
9. ROOT ALMOST COMPLETED- OPEN APEX
8. TWO-THIRDS OF ROOT COMPLETED
7. ONE-THIRD OF ROOT COMPLETED
6. CROWN COMPLETED
5. CROWN ALMOST COMPLETED
4. TWO-THIRDS OF CROWN COMPLETED
3. ONE-THIRD OF CROWN COMPLETED
2. INITIAL CALCIFICATION
1. PRESENCE OF CRYPT
0. ABSENCE OF CRYPT

Fig. 1 Calcification stages of the mandibular canine and premolars (after Nolla).

la[7] (Figure 1), were determined to the nearest stage. (2) Using the method of Shumaker and El Hadary[9] (Figure 2), per cent of eruption was determined from each radiograph for each tooth. The limits for the measurements were the inferior border of the mandible, and an arc passing through the cusp tip of the primary canine and the buccal cusp tips of the primary molars. The lines along which the measurements were made passed through the cusp tips of the unerupted permanent teeth and the centers of the crowns of their primary predecessors. Eruption per cent as used was not a perfect measure of eruption because it was affected by growth of the alveolar processes and inferior border of the mandible, and by occlusal attrition. It was used because it was considered the best possible measure of eruption with the available lateral jaw radiographs.

On the casts the following measurements were made, as shown in Figure 3: (1) the mesiodistal width of each permanent tooth anterior to the first permanent molar on the right side of the dental arch; and (2) the distances from the mesial surface of the right first permanent molar to the mesial contact of the right permanent canine, and from there to the mesial contact of the right central incisor. The sum of the two segments of the dental arch minus the sum of the tooth widths, expressed as a positive or negative number to the nearest tenth of a millimeter, was recorded as the right side dental arch space adequacy. Any tooth which appeared to be rotated or out of the line of the arch was recorded as a malposed tooth. All measurements on the radiographs and casts were made to the nearest tenth of a millimeter with a finely pointed vernier caliper.

The measuring procedures used were the result of an error study in which each method of measurement under consideration was performed twice,

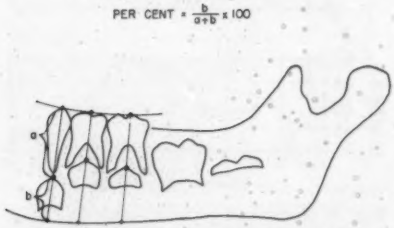


Fig. 2 Per cent of eruption (after Shumaker and El Hadary).

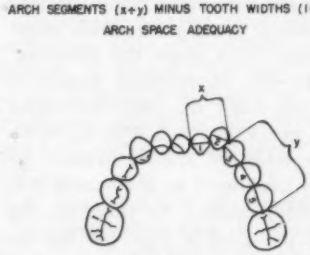


Fig. 3 Right side dental arch space adequacy.

with a one-week interval between measurements, on ten of the record series which had been selected at random. (1) When per cent of eruption was determined from measurements of tracings of the radiographs, the mean error (the mean difference between the first and second measurements) was 1.2 per cent, but when the measurements were performed directly on the radiographs, the mean error was .8 per cent. This difference between means could have occurred by chance only 5 per cent of the time[11]. (2) When right side dental arch circumference was measured, using the two segments as previously described, the mean error was .3 mm, but when circumference was measured from one tooth contact to the next around the arch, the mean error was .7 mm. This difference between means could have occurred by chance only 1 per cent of the time. Though the two segment method was more reliable, it averaged .3 mm smaller. (3) The mean error in reading calcification stages was .2 stage, and (4) the mean error for the sum of the mesiodistal measurements of the five teeth was .6 mm.

Eruption and Calcification

Figure 4 shows the mean eruption per cent and calcification stage with their standard deviations and sample size at each yearly age plus or minus one month; and Figure 5 indicates the mean eruption per cent and monthly age with their standard deviations and sample size at each calcification stage. The mean values show the following. The per cent of eruption begins to increase by stage six, and the canine and first premolar reach stage six about the same time (74 and 75 months, respectively) followed by the second premolar (84 months). At stage six the eruption per cent is least for the canine (50 per cent), next for the second premolar (57 per cent), and greatest for the first premolar (61 per cent). All three teeth near 100 per cent eruption at stage nine, and the canine reaches stage nine first (140 months) followed closely by the first premolar (144 months) and then the second premolar (151 months).

The ages of attaining 100 per cent eruption are about one year greater than the eruption ages found in previous studies, which had designated a

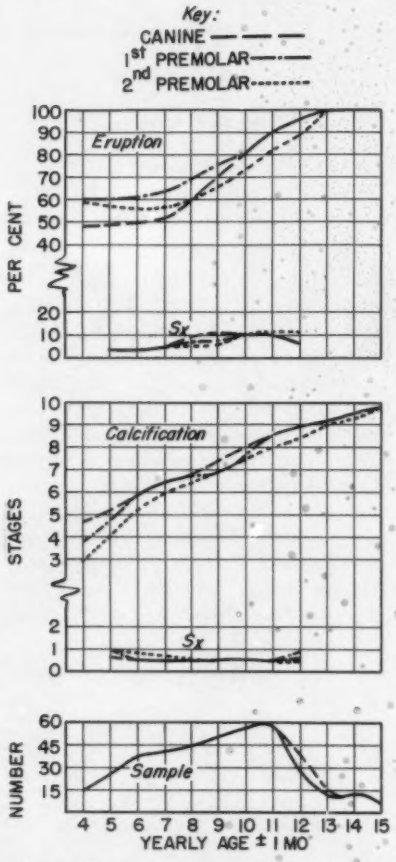


Fig. 4 Mean per cent of eruption, mean calcification stage, and their standard deviations (Sx), and sample size at each yearly age plus or minus one month.

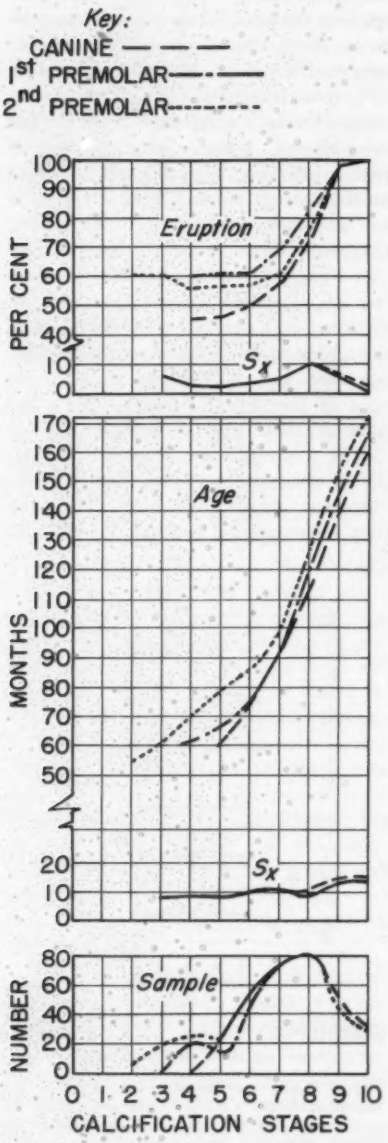


Fig. 5 Mean per cent of eruption, mean age in months, and their standard deviations (Sx), and sample size at each calcification stage.

tooth erupted as soon as it was visible in the oral cavity. The decrease in eruption per cent shown by the second premolar around five years of age is probably the result of alveolar growth which would cause measurement "a" to increase. The canine and first premolar did not show this decrease in eruption per cent, possibly because they had already begun to erupt; and the inferior border of the mandible may have had some appositional growth[12,13] which would have tended to increase eruption per cent by increasing measurement "b". Ninety-five per cent of the sample fell within the limits of about plus or minus two and one-half years of the mean time of attaining 100 per cent eruption of each of the three teeth. The individual variation in per cent of eruption appears to be less when measured at calcification stages than when measured at years of age plus or minus one month, and variation seems to increase around stage eight, the period of most rapid eruption.

Crowding

The distribution of the casts and of the malposed teeth in relation to dental arch space adequacy is shown in Figure 6. The range of right side dental arch space adequacy was from plus 6.8 mm to minus 3.9 mm. There were no canines or premolars which did not erupt to the plane of occlusion.

The relationships between dental arch space adequacy, and eruption and calcification were investigated by analyzing seven pairs of variables cross-sectionally at periodic intervals for each of the three teeth to determine whether there were significant correlations. The pairs of variables examined were as follows:

1. Age (months) of attaining each calcification stage with right side dental arch space adequacy (mm) in the permanent dentition.

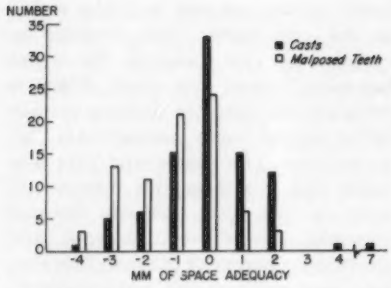


Fig. 6 Distribution according to right side dental arch space adequacy of 89 casts and 81 malposed teeth which were found on 53 of the casts.

2. Age of attaining each calcification stage with rate of eruption (per cent per year plus or minus one month).
3. Space adequacy with rate of eruption at successive intervals.
   a. Per calcification stage at each stage.
   b. Per year plus or minus one month at each stage.
   c. Per year at each yearly age plus or minus six months.
   d. Per year plus or minus one month at each yearly age plus or minus six months.
4. Space adequacy with eruption (per cent) at successive intervals.
   a. Each calcification stage.
   b. Each yearly age plus or minus one month.
   c. Each ten months plus or minus five months.
5. Space adequacy with measurement "a" (mm) (Figure 2) at each stage.
6. Space adequacy with measurement "b" at each stage.
7. Space adequacy with measurement "a" plus measurement "b" at each stage.

Scatter diagrams for each pair of variables for each tooth at each interval were made whenever the sample size exceeded twenty. When any correlation between variables was suggested by the scatter diagram, the correlation coefficient (r) and the probability (P) that it might have occurred by chance were calculated[11]. All of the calculations, which were performed with a machine, and all entries of data on the calculation sheets were repeated for accuracy. Out of the 181 scatter diagrams there were 37 correlations (see Figure 7) with coefficients exceeding .10, but none greater than .43, indicating considerable individual variation. Nine of the correlations could have occurred by chance less than 5 per cent of the time (P equals .05), and none of these had a coefficient below .30 or a sample size smaller than 47. All of the nine occurred between calcification stages four and eight, and they constituted 8 per cent of the 117

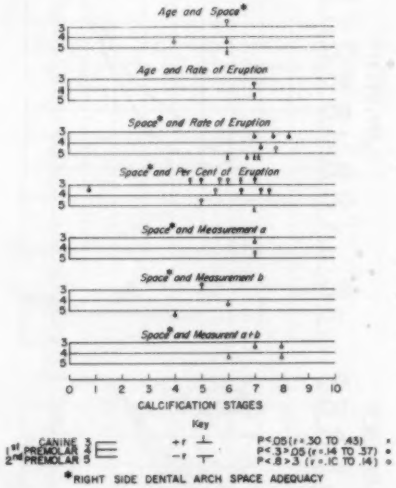


Fig. 7 Positive or negative correlations and the probability (P) of their occurring by chance in the 37 instances in which the paired variables had a correlation coefficient (r) exceeding .10. This is recorded at the calcification stages at which the correlations occurred. Data recorded in months were converted to the mean calcification stage for that age.

scatter diagrams between these stages; and of the nine, seven could have occurred by chance less than 2 per cent of the time, and four less than one per cent of the time. Although there were more correlations with coefficients exceeding .10 for space adequacy with rate of eruption, and space adequacy with per cent of eruption than for some of the other pairs of variables, these two had three or four times as many scatter diagrams.

Greater importance was attached to the correlations which had a lesser probability of having occurred by chance, but it was also noted that most of those correlations with a greater probability of having occurred by chance conformed in sign to the overall pattern. With reduction in space adequacy (1) the mandibular canine had a retarded eruption per cent around calcification stages five through seven (space with per cent of eruption). With reduction in space adequacy (2) the mandibular second premolar reached stage six at a later age (age with space), but (3) at stages six and seven its rate of eruption was greater (space with rate of eruption), and (4) by stage seven its eruption per cent was greater (space with per cent of eruption), and (5) it was closer to the occlusal plane (space with measurement "a"). Also (6) when the second premolar reached stage seven late, its rate of eruption was greater (age with rate of eruption).

It is not possible from the findings definitely to conclude casual relationships, but several may be hypothesized. (1) Retarded eruption of the canine or retarded calcification of the second premolar might permit excessive mesial drift of the permanent first molar and primary molars, reducing arch circumference; or inversely, crowding may be causing retardation of eruption, but it does not seem likely that crowding could retard calcification. (2) The accelerated eruption of the second premolar following retardation of its calcification might be because the roots of the primary second molar have had longer to resorb. (3) The correlations diminish by stage eight, and it could be either that the eruptive process has exerted its main influence on space adequacy by that stage, or that the eruptive process is no longer affected by space inadequacy after stage eight.

Individual variation, as indicated by the low correlations, appears to be too great for it to be practical to attempt to use calcification stages, eruption per cent, or eruption rate to predict crowding in the mandibular permanent dentition, or to be concerned about the eruption timing of the mandibular canine and premolars being affected by moderate crowding.

Summary

Using a sample of eighty-nine boys from the University of Michigan Elementary School Growth Study, an average of seven annual lateral jaw radiographs for each individual along with dental casts were measured and analyzed cross-sectionally to determine the relationship between dental eruption, dental calcification, and dental arch crowding for the mandibular canine and premolars.

Tables relating eruption and calcification were compiled indicating mean values and individual variation. The means showed the following: (1) The canine and premolars began erupting when their crowns were complete, and reached the occlusal plane just prior to completion of their roots. (2) The canine and first premolar began and completed eruption at approximately the same times, followed by the second premolar. (3) At the same time eruption began, the order of proximity to the occlusal plane was first premolar,

second premolar, and canine. The data used in this study may be analyzed longitudinally to permit a more accurate prediction of eruption times from calcification stages.

Increased crowding in the mandibular permanent dentition had a low but significant correlation with (1) retardation of the early phases of eruption of the canine, and (2) retarded calcification of the second premolar, followed by an acceleration of the early phases of its eruption.

Individual variation was so great that it appears to be impractical to predict crowding from calcification or eruption timing, or to be concerned about moderate crowding affecting eruption timing.

511 Columbia Bldg.

BIBLIOGRAPHY

1. Cattell, P. Dentition as a Measure of Maturity. Cambridge, *Harvard University Press*, Harvard Monographs in Education, No. 9, 1928. viii +91 p.
2. Cohen, J. T. The Dates of Eruption of the Permanent Teeth in a Group of Minneapolis Children. *Am. Dent. A. J.*, 15:2337-41, Dec. 1928.
3. Klein, H., Palmer, C. E., and Kramer, M. Studies on Dental Caries. II. The Use of the Normal Probability Curve for Expressing the Age Distribution of Eruption of the Permanent Teeth. *Growth*, 1:385-94, Dec. 1937.
4. Hurme, V. O. Ranges of Normalcy in the Eruption of Permanent Teeth. *J. Dent. Child.*, 16:11-15, 2nd Quar. 1949.
5. Lo, R. T., and Moyers, R. E. The Sequence of Eruption of the Permanent Teeth. *Am. J. Ortho.*, 39: 460-67, June 1953.
6. Garn, S. M., and Lewis, A. B. Relationship Between the Sequence of Calcification and the Sequence of Eruption of the Mandibular Molar and Premolar Teeth. *J. Dent. Res.*, 36:992-95, Dec. 1957.
7. Nolla, C. M. The Development of Permanent Teeth. In Press.
8. Carlson, H. Studies on the Rate and Amount of Eruption of Certain Human Teeth. *Am. J. Ortho.*, 30:575-88, Nov. 1944.
9. Shumaker, D. B., and El Hadary, M. S. Roentgenographic Study of Eruption. *J.A.D.A.*, 61: 535-41, Nov. 1960.
10. Richards, A. G., and Alling, C. C. Extraoral Radiography: Mandible and Temporomandibular Articulation. *Dent. Radiog. and Photog.*, 28:1-7, No. 1, 1955.
11. Fisher, R. A. Statistical Methods for Research Workers. London, Oliver and Boyd, 1946. xv + 354 p.
12. Brash, J. C. The Growth of the Jaws and Palate. Chapter V of Five Lectures on the Growth of the Jaws, Normal and Abnormal, in Health and Disease. London, *Dental Board of the United Kingdom*, 1924.
13. Craven, A. H. Growth in Width of the Head of the Macaca Rhesus Monkey as Revealed by Vital Staining. *Am. J. Ortho.*, 42:341-62, May 1956.

Problems And Promises Of Basilar View Cephalograms

H. Berger, Dr. Med. Dent.
Tel-Aviv, Israel

Introduction

Cephalometric roentgenology has been in use now for more than thirty years. But through all these years the lateral view only has been utilized. The syllabus by Krogman and Sassouni describes more than forty diagnostic methods, all of them concerning the profile roentgenogram. The authors themselves are aware of this fact, "Generally speaking, in roentgenographic cephalometry, breadths and heights have been relatively neglected in favor of the anteroposterior or depth dimensional changes. Maybe a factor responsible for this situation is the Angle classification. The focus in this classification is put on the anteroposterior relationship of the teeth, the dental arches and sometimes the jaws. It was but natural that the first investigations on facial growth were in turn focussed on the anteroposterior changes and especially their repercussions on the profile."

Schwarz in his recent publication *Die Roentgenostatik* of some hundred pages devotes exactly one third of one page to the "Roentgenvorderbild" (anteroposterior roentgenogram).

It is understandable that at first investigations were concerned with the profile view, where not only changes of growth and development were easily appraised, but also where changes due to treatment could be very effectively demonstrated. However, it seems to the author that the possibilities of the profile view have been greatly exhausted; if we heed Salzmann's admonition, "Cephalometrics is a means of obtaining information; it is not an end in itself", then one might well benefit from looking for new approaches.

That the anteroposterior film has been badly neglected has just been stated, but there is a third view which up to now has never been used at all, the basilar view. Of course, pictures in this view cannot be taken so easily as in the other two directions but on the other hand they are not as complicated either, especially in children who are elastic and flexible.

Roentgenologic Technique of Basilar View Cephalograms

The roentgenologic technique for the basilar view has been described as early as 1905 by Schueller who used the term "Submento - vertical position". He recommended two ways, with the patient either lying on his back or sitting. To ensure complete immobility of the patient, the first method has been adopted in the present study. It has, however, been amended by using a head rest set at an angle of 25° to ease the patient's rather awkward position (Fig. 1). In order to obtain uniform pictures a quite simple appliance has been attached to this board to serve as a cephalometer. The main part is a face-bow with movable pointers which can be aimed at the poria and the orbital points. This face-bow slides up and down parallel to the board which also serves as cassette holder. Thus the pictures are oriented in the Frankfort horizontal plane. A fifth pointer can be moved up and down a slit in the rod which supports the face-bow. It has to be fixed against the nasal root and thus ensures sagittal orientation in the

Fig. 1
The cephalograms connected with this study have been made by Dr. S. Harris, radiologist, to whom the author is greatly indebted for his help and cooperation.

midline. The central ray is directed towards the middle of a line connecting the two porıa. The distance between tube and cassette is 1.50m.

Originally small lead balls were incorporated into the plastic pointer tips. This device was intended to facilitate first orientation. It soon became clear that the film itself provided sufficient landmarks and, in order not to encumber the picture unnecessarily with extraneous features, this device was soon abandoned.

The Zygomatic Arch.

At first attentions were directed toward the appearance of the zygomatic arch in the basilar view, as the author has always been intrigued by the connection of the zygomatic arch with the masticatory system (Fig. 2). The importance of this relationship shall be stressed here once more by a short recapitulation of some investigations devoted to the subject. The relationship between zygomatic arch and teeth has been mentioned by Klaatch as early as 1909. Klaatch explained that generally the maxillary extension of the arch aims toward the mesiobuccal root of the first upper molar. In primitive people, however, this place is taken up by the distal root. Two years later Bluntschli described the relationship between the maxillozygomatic ridge and the dental arch during the period of growth. He found that the tooth most subjected to masticatory stress was always positioned below the ridge. Thus at the time of the deciduous dentition the second milk molar is to be found below the insertion of the ridge; a forward shift of the dentition brings the first molar into this place. These observations have been confirmed and their range extended by Broadbent in his study about the ontogenetic development of the occlusion. In a series of tracings the shift of the dentition in relation to the ridge can be beautifully followed from the age of one and one-half years when the first deciduous molar is below the ridge to the age of eighteen, when the first permanent molar finally occupies this place.

In the middle twenties Izard and the author simultaneously, but separately, showed that the bizygomatic arch width was numerically related to the alveolar width and could be used for diagnostic purposes. In a paper "Orthodontics as a Life Factor" (1941) At-

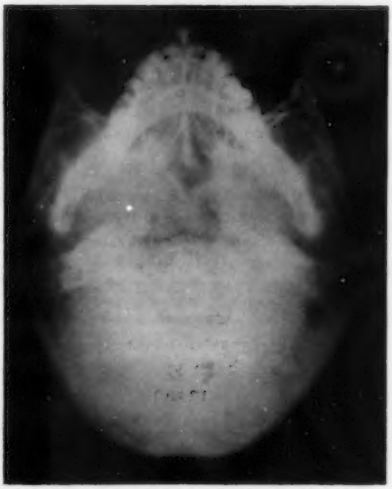


Fig. 2 Cephalogram in basilar view.

kinson once more called attention to the importance of the zygomatic arch. Referring to the connection between the alveolar - zygomatic ridge and the first molar on the one hand and to the importance of the molar as a key tooth on the other hand, he coined the expression "key ridge". At the same time he warned that "the mathematically minded orthodontists will find difficulty in using this landmark; it can never be said to be found so many millimeters from that point, nor can it be said normally to descend from the zygoma at an angle of a set number of degrees. Distances between points are constantly changing in growing skulls and, as skulls are individually of different shapes, various landmarks may not be said universally to be so many millimeters apart."

As the investigations by Izard and the author had at that time been published for some fifteen years, this remark might refer to the difficulties of using the key ridge in roentgenographic cephalometry. These difficulties consist in the fact that the ridge is not sharply defined, but is of rather vague shape and that in addition to this one gets — in the lateral view — two shadows, one for the ridge nearest to the film, the other for that on the far side.

The Point: "Buccale."

At first glance one gets the impression as if in the basilar view too the bizygomatic arch were not quite clearly defined. Especially in children where the arch is not yet fully developed it is overshadowed by the walls of the skull; particularly the determination of the most lateral points, used in the methods of both Izard and the author, would meet with difficulties. There is, however, an alternative to the most lateral point, the most forward one. It is situated where the interior surface of the arch turns medially and directly

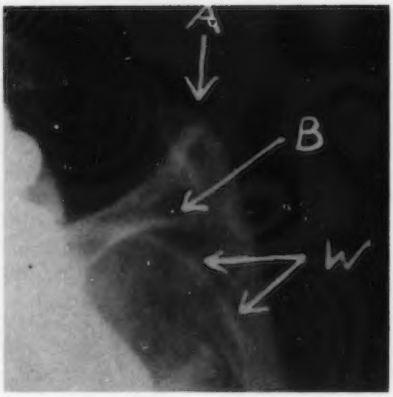


Fig. 3 Basilar view cephalogram of anterior zygomatic arch region with landmarks. A — Angulare, B — Buccale, W — Wing lines.

starts upon a backward sweep. This curve is well discerned in the basilar view, and it would be convenient to give a proper name to its most forwardly situated point. The term "Buccale" is proposed (Fig. 3). It is to be differentiated from other points connected with the zygomatic arch. "Jugale" is situated at the upper rim where this turns upward towards the orbita. "Zygion" is the most laterally protruding point of the zygomatic arch; it is this point which is used for the determination of the bizygomatic breadth. "Zygomaxillare" is called the lowest point of the maxillozygomatic suture; it does not show on the film. A point "Malare" has been introduced by Sassouni which is the "midpoint of the intersection between the projection of the coronoid process and the lower contour of the malar bone." It is used on the anteroposterior film.

If we connect the buccale points of both sides, we get a line which can be regarded as a cross section of a plane erected perpendicularly to the Frankfort horizontal plane, the "Buccale plane". The line can also be drawn as

a tangent to the curves representing the lower anterior rims. This method may be used to advantage when the curves do not show a sharp bend.

The importance of this plane lies in the fact that it cuts the alveolar arches in the region of the first molars. While measurable relationships between the zygomatic arches and these teeth were restricted to the width dimension, it will now become possible by using the same picture to study the relations in sagittal direction and to interrelate the results.

Until now investigations of this type had to use a lateral as well as frontal film to compare the results and recourse had to be made to perspective drawings. This laborious way, for instance, has been taken by Sassouni in his interesting study of the position of the upper first molar.

In this connection the findings of Potter and Meredith should be remembered, i.e., that sometimes measurements on the roentgen picture may give better results than those taken anthropometrically. While waiting for the accumulation of more material and its statistical evaluation, the author at present is inclined to believe that in the upper jaw the external alveolar width, where cut at a given time by the buccale plane, is approximately two-thirds of the width of this plane, i.e., the interbuccale distance.

The A, B, C Lines: Angulare, Buccale, Condyle Planes.

While the buccale plane seems to be a most promising landmark, there are, of course, others which may be useful. One of them is where, at the external orbital angle, the upper and lower rims of the orbita meet and together with the insertion of the zygomatic arch produce a dense area of triangular shape. The term "Angulare" is proposed for the tip of this density. A connection of angulare points of both sides would give a line which could be regarded as a cross section of an angulare plane. This plane cuts the dental arch in the cuspid-premolar region and will be a useful complement to the buccale plane connected with the molar region.

Backwards a tangent touching the distal contours of the condyles would give us a condyle plane which would facilitate the study of the position of the mandible in relation to the skull. The interrelation between these three planes should give us interesting information. For though all three planes belong essentially to the face, there is a difference between them in so far as the positions of the angulare and condyle planes are decisively influenced by the anterior and posterior parts of the cranial base respectively. It is the buccale plane only which is independent and which is particularly characteristic for the face because of the fact that an axis through the two buccale points would be nearer to the center of the face.

The Wing Lines.

By contrast there is a valuable landmark which belongs to the neurocranium entirely. It is easily recognized and always well defined: the outline of the anterior walls of the middle cerebral fossae. As these walls are mainly composed of the wings of the sphenoid bone, the name *wing lines* might be suitable. These lines together with the above discussed group should prove valuable when there is the question of investigating the relation between the visceral and neural parts of the skull under normal and abnormal conditions.

They may also be of special importance in longitudinal studies, in a way comparable to De Coster's base line. It seems very probable that the outline of these wings will show no change after seven or eight years of age

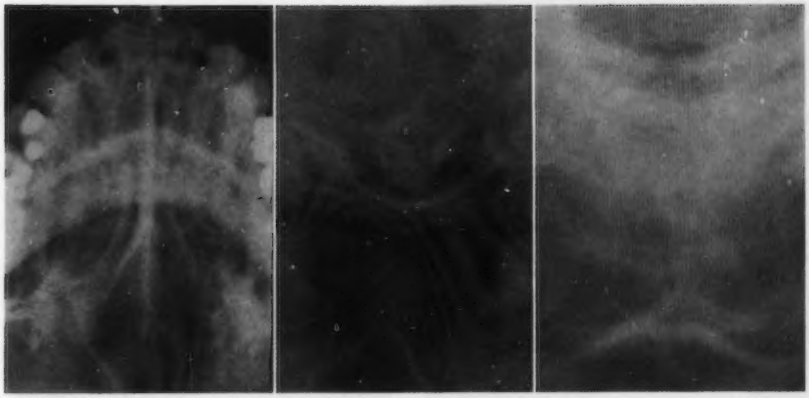


Fig. 4 Landmarks used for determination of sagittal midline. Left, Crista frontalis, crista galli and vomer. Center, Tubercle of atlas and odontoid process of epistropheus. Right, Crista occipitalis interior.

as is the case with the base line in the profile view. The author is supported in this assumption by the findings of Brodie about the stability of the cranial base, especially in this region.

Midlines.

Another and perhaps the most obvious use of a basilar film would, of course, be for the determination of a midline and the assessment of asymmetry. There are a number of points which qualify for this purpose: the anterior tubercle of the atlas, the odontoid process of the epistropheus and the outline made by the vomer and crista galli (Fig. 4). In addition to these, two characteristic features on the inner walls of the frontal as well as the occipital bone can help in the determination of the midline. These are the indentations in the outline of these bones caused by the crista frontalis and crista occipitalis interior respectively. As absolute symmetry in a skull scarcely exists, it will not be possible to draw a straight line through all these points. Some sort of interpolation is needed and, with the use of the above mentioned points, easily made.

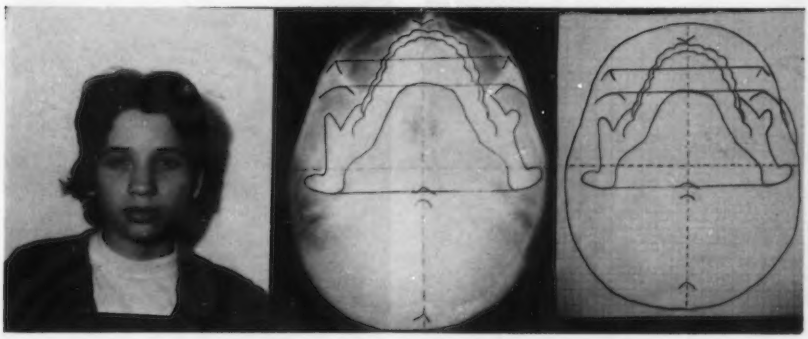


Fig. 5 Appraisal of asymmetry: face with marked asymmetry, cephalogram and tracing.

Fig. 6 Models and cephalogram of a boy with severe distoclusion; A, B, and C indicate the position of the angulare, buccale and condylar planes, W, the wing lines (dotted).

Fig. 7 Models and cephalogram of a boy with normal dentition.

For reference in the anteroposterior direction a transversal line through the sella had originally been envisaged in conformity with the prominence which this landmark enjoys in cephalometric roentgenology. But it soon became apparent in the course of the investigation that the outline of the sella and/or the end of the clivus were not always clearly definable, the variable formation of the sphenoid sinus interfering. As recent critical investigations by Baume have undermined the position of the sella anyway, this attempt was soon abandoned and a transversal midline through the center of the sagittal midline and perpendicular to it was introduced. This puts at our disposal a coordinate system which should be helpful in solving some of our problems (Fig. 5).

Analysis of Distoclusion.

In this context only one recurring question should be mentioned: the relative importance of the upper or lower jaw respectively in the etiology of distoclusion.

Figures 6 and 7 show models and cephalograms of two boys of approximately the same age. It will easily be seen that in both cases the upper first molars have almost the same relationship to the buccale plane. The angulare plane, too, cuts the upper alveolar arches in the same region. On the other hand we find that the condyle plane in the normal case is practically coincident with the transversal midline, while in the distoclusion case it is about one-sixth of the head length behind the transversal midline, i.e., about one inch towards the back. On the basis of these findings we should come to the conclusion that in this case distoclusion is caused by, or at least connected with, an extreme backward position of the glenoid fossae, while the upper arch is normally placed with respect to the angulare and buccale planes.

Teeth and Dental Arches.

Finally the fact should be stressed that individual teeth can be more easily identified here than in the lateral view, where the teeth of the two sides cannot be distinguished, while in the frontal view they are projected over each other anteroposteriorly. We can simplify our task still more by placing some separating wires at the upper and/or lower molars, or we can even delay taking the picture until some distinguishing parts of the appliance have been fixed (Fig. 6).

In cases where we are interested in the upper jaw only, as for instance in the studies of the upper first molar, we can get still clearer pictures if they are taken with the mouth open. Another possibility is to have the patient open the mouth during the exposure. Then the shadow of the mandible is eliminated. One gets, of course, a slightly blurred picture, but this disadvantage is more than compensated by an unrestricted view of the upper jaw which in cleft palate cases is quite important. Not only the position and extent of the cleft is seen clearly, but also the existence of unerupted and/or supernumerary teeth is easily diagnosed (Fig. 8).

The appearance of the dental pattern in basilar cephalograms should be useful too when used for identification purposes. In addition to the plenitude of sagittal and transversal diameters, this pattern together with the outlines of head and mandible could be used in a final analysis.

Conclusion

At the end of this paper which is in the nature of a provisional report, the author expressly wants to state that in spite of the fact that certain lines could be represented as A, B, C lines, he is

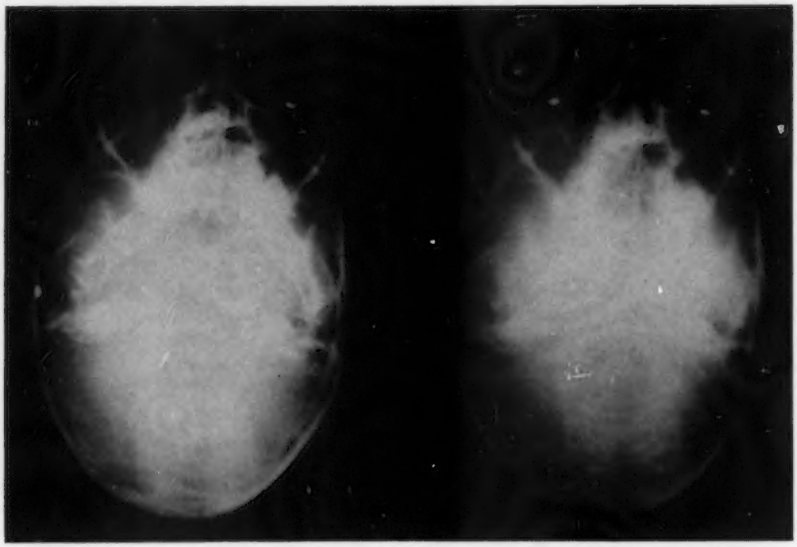


Fig. 8 Basilar view cephalogram of a cleft palate: Left, mouth closed; Right, mouth being opened during exposure.

far from the idea that by this the ABC of basilar cephalometry has been evolved. This is just a beginning. As indicated in the title certain problems of this method and its promises have been discussed. If only part of the endeavour and ingenuity devoted up to now to the lateral view is transferred to the basilar view, some of the problems should be solved and some of the promises realized in not too long a time.

69, Rothschild Blvd.

BIBLIOGRAPHY

1. Atkinson, S. R.: Orthodontics as a Life Factor. *Am. J. Ortho.* and *Oral Surg.* 25:1133-1142, 1939.
2. Baume, L. G.: A Biologist Looks at the Sella Point. Transact. *Europ. Ortho. Soc.*, 1957.
3. Berger, H.: Massbeziehungen Zwischen Schaedel-und Zahnbogenbreite (Vorlaeufige Mitteilungen). Zahnaerztl. Rundschau 35, 1926.
4. Berger, H.: Untersuchungen ueber das Verhaeltnis der Schaedelbreite zur Zahnbogenbreite. Correspondenz-Blatt f. Zahnaerzte 51, 1927.
5. Berger, H.: Twenty-five Years' Experience with the Zygomatic Method. *Am. J. Ortho.* 38: 369-381, 1952.
6. Bluntschli, H.: Das Platyrrhinengebiss und die Bolksche Hypothese von der Stammesgeschicht des Primatengebisses. Verhandlungen der Anatomischen Gesellschaft. Zuerich, 1911.
7. Broadbent, B. H.: Ontogenic Development of Occlusion. *Angle Ortho.* 11:223-241, 1941.
8. Brodie, A. G.: Behavior of Normal and Abnormal Facial Growth Patterns. *Am. J. Ortho.* and *Oral Surg.* 27:633-647, 1941.
9. Brodie, A. G.: Late Growth Changes in the Human Face. *Angle Ortho.* 23:146-157, 1953.
10. De Coster, L.: La Croissance de la Face et des Dents. *L' Orthodontie Française* 23, 1952.
11. Franklin, J. B.: Radiographic Phenomena in Cephalometric Roentgenography. *Angle Ortho.* 27:162-170, 1957.
12. Izard, G.: Orthodontische Diagnostik. *Fortschr. d. Orthodontik.* 3: 215 - 229, 1933.
13. Izard, G.: *Orthodontie. Paris*, 1939.
14. Klaatsch, H.: Kraniomorphologie und Kraniotrigonometrie. *Arch. f. Anthropologie*, 1909.

15. Krogman, W. M. and Sassouni, V.: Syllabus in Roentgenographic Cephalometry. Philadelphia, 1957.

16. Merrill, V.: Atlas of Roentgenographic Positions. St. Louis, 1949.

17. Potter, J.W. and Meredith, H. V.: A Comparison of Two Methods of Obtaining Biparietal and Bigonial Measurements. *J. Dent. Res.* 27:459-466, 1948.

18. Salzmann, J. A.: The Research Workshop on Cephalometrics. *Am. J. Ortho.* 46:834-847, 1960.

19. Sassouni, V.: Position of the Maxillary First Permanent Molar in the Cephalofacial Complex. *Am. J. Ortho.* 43:477-510, 1957.

20. Schueller, A.: Die Schaedelbasis im Roentgenbild. Fortschritte auf dem Gebiet der Roentgenk. 11, 1905. (Quoted after Merrill)

21. Schwarz, A. M.: die Roentgenostatik. Wien, 1958.

22. Shapiro, F. and Janzen, A. H.: The Normal Skull. A Roentgen Study. New York, 1960.

Reduction And Fixation Of Facial Fractures

ROBERT F. SCHOENWETTER, D.D.S., M.S.
Oshkosh, Wisconsin

The reduction and fixation of facial fractures requires a deep knowledge of bone response, muscle activity and function of the anatomical structures involved. One cannot hope to obtain the goal of functional occlusion in fracture reduction unless he understands the normal action and function of the associated anatomical parts.

I wish to present a group of cases which will illustrate the problems involved, the difference of opinions with regard to reduction and how to accomplish it. These opinions exist as to the type of mechanical appliances to be used and the philosophy of the reduction.

Condylar fractures seem to be the most controversial type of fractures encountered.

In fracture dislocations, Waldron (1942) believed that intermaxillary ligation gave satisfactory results. Ruedi (1928), in cases seen at the Zurich University Clinic, did not find any serious disturbance after conservative treatment of fracture dislocations. Therefore, he advised leaving the condyle in a dislocated position. Steinhardt (1936) believed that in such cases, as a result of function, the dislocated condyle would be rebuilt and form a new, well-functioning joint. Perthes (1942) and Wassmund (1934) found the occlusion to be unsatisfactory, with a tendency to open-bite, and mastication and lateral excursions of the mandible hindered. They described a peculiar appearance of the face when the patient masticated food pointing out that, in many cases, the fragments may be so displaced that union is impossible. Both writers advised surgical interference for good, anatomic results. In some instances the functional result from conservative treatment is so poor that Perthes recommends an osteotomy of the ramus to correct this deformity.

In children the successful treatment of fractures of the condyle by conservative wiring method has been reported by Brown and Hamm (1932) and Thoma (1938). These are frequently of the greenstick type, but may be complicated by dislocation. Operations on a child's condyle may interfere with epiphyseal growth of the jaw and therefore should be avoided. I have found that, in children, a good final result may be spontaneous, after a year or two, if the fracture, treated conservatively, heals in malposition.

Bellinger says that in cases of complete disarticulation of the condyle, the condyle will be drawn out of its normal position in a medial anterior direction until it is out of contact with the ramus of the mandible; perfect occlusion, perfect excursion and perfect function do not always follow. Function may be adequate but final function has not always been what could be desired.

The only muscle attached to the condyle is the unopposed external pterygoid, one of the reasons why the condyle may be drawn out of normal position.

Henny states that, "Conservative therapy consists of the simple immobilization of the jaws or immobilization with an interposing pad between the teeth."

The bad effects of conservative treatment may be:

Read before the Mid-Western Component of the Angle Society, January, 1959.

1. Deviation towards the affected side upon opening.
2. Inadequate opening.
3. Ankylosis

Complications involved in surgical reductions are:

1. Lack of adequate access inferiorly.
2. The medial aspect of the condylar head is not available.
3. Repeated damage to one of the ramifications of the facial nerve.

To have a well-healed fracture accompanied by a partial paralysis of the face is certainly no surgical triumph.

Surgical treatment would be the choice of treatment if the following dictums could be met:

1. The operation must promise a better result than by conservative treatment.
2. Operation would not unduly endanger the facial nerve.
3. Procedure would not further damage the meniscus.
4. Condyle would remain after repositioning.

The line of surgical approach has been preauricular. Another approach is the incision at the angle of the mandible.

The methods used in facial fracture reduction are:

1. Transosseous wiring
2. Bone plates
3. Extra-skeletal fixation
4. Orthodontic.

Thoma states that in "fractures at the angle of the jaw with upward or lateral displacements of the ramus the transosseous wiring is superior to the splint with extension arm pressing the ramus back and inferior, and to the traction method with a wire inserted in a hole at the angle of the jaw attached to a rod extended from a headcap".

Bone plates are used mostly in edentulous jaws or sections of the jaw. Bone plating, like transosseous wiring, must be supported by immobilization. Reliance on the bone plates alone for fixation of the fracture in most cases will end in failure because of undue strain brought on the plate during functional movements of the jaw.

Correct occlusal function is today generally accepted as the goal of fracture reduction, not bone apposition.

Regardless of the number of facial fractures present, many times one or both of the mandibular condyles are involved. In the reduction of condylar fractures one must oppose the resulting Class II tendency in the occlusion due to the shortening of the mandibular length. Many fractures of the condyle only are missed in the initial radiographic examination. These fractures usually make themselves known in two or three weeks time through function as mandibular movements and the occlusion are changed.

The fracture cases which I wish to present were reduced with the edgewise orthodontic appliance. All teeth within reason were banded for the most anchorage. The fractured segments were moved as units into apposition by orthodontic mechanics which permitted exact control of each segment. Expansion arches, contracting arches, torque, closing and opening loops, coil springs, elastics, and routine orthodontic tying were forces used in the reduction.

Contrary to the usual method of orthodontic procedure, complete records, except x-rays, are not taken in fracture cases. The first responsibility to the patient is the reduction of the fracture and his comfort. The patients one is called upon to treat in hospitals are frequently from distant areas. For this reason one does not attempt to secure complete records such as photographs and models. The x-rays, of course, are always available from the hospitals.

Mandibular Condylar Fractures

Case No. 1 was a young lady, age 20, who had been injured in a car accident. She suffered a compound fracture of the femur and of the neck of the right mandibular condyle. The head of the condyle was displaced medially into the infratemporal fossa. A full edgewise orthodontic appliance was placed, each tooth banded in order to distribute the force of the elastics. Passive .0215 x .028 gold arches with hooks for vertical and Class II elastics were tied into place. The Class II elastics opposed the hyoid group of muscles which tend to pull the mandible downward and backward. After the mesiodistal reduction had been accomplished, vertical elastics were placed to hold the teeth in occlusion. A rubber pad, one-eighth inch thick, was placed between the maxillary and mandibular right molars to relieve the pressure at the fracture site. If this step is not done, the masseter and internal pterygoid muscles pull upward and prevent any uprighting of the fractured condyle. Reduction is accomplished usually between six and twenty-four hours. The elastic tension fatigues the muscle trismus and permits the mandible to assume its normal spatial position. The occlusion was readily brought back to normal and held for ten days. The intermaxillary elastics were then removed and she continued on a liquid and soft diet for several weeks.

It has been the practice to release early the fixation in condylar fractures because of the danger of ankylosis. It is thought that if they are held rigidly for a period of six weeks, as is customary in facial fractures, ankylosis of the joint may occur.

As condylar growth was not a factor in this case, no problems were foreseen. Upon opening the normal width as during speech, no deviation is noticeable. However, upon wide opening the mandible opens normally up to a point, and then deviates to the right. She has lost the ability to protrude anteriorly, but has had no temporomandibular soreness or pain.

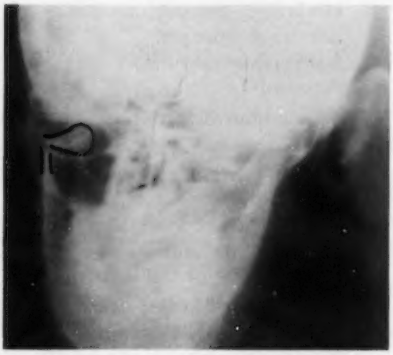


Fig. 1 Photograph of the frontal headplate showing the displacement of the condylar segment into the infratemporal fossa.

Figure 1 is a photograph of the frontal headplate showing the condylar fracture and its displacement into the infratemporal fossa.

It has been six years since the accident and there is no evidence of temporomandibular disturbance to date.

Case No. 2 was a case of a young girl, age 11, who had been injured in a bicycle accident. Radiographic examination revealed a fracture of the neck of the right condyle, almost identical to the above patient. However, because of the young age, the problem of future condylar growth was of most importance.

The occlusion was reduced and fixed for a period of seven days. The intermaxillary elastics were then removed and slight function was encouraged.

An acrylic bite plane was later placed to guide the occlusion. The tracings of lateral headplates show that the mandible has grown downward and forward; however, the amount is small and it is impossible to show any difference between the right and left side.

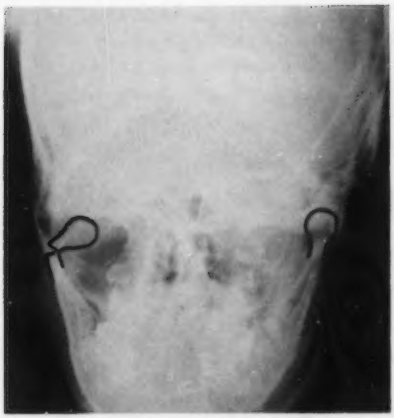


Fig. 2 Photograph of the frontal headplate showing the displacement of the right condyle into the infratemporal fossa.

Tracing of the frontal headplate again shows little asymmetry; clinically, the right buccal segment still tends toward a Class II occlusion which indicates less mandibular growth on the right side. To date, six years after the accident, no temporomandibular disturbance is present. She opens normally to a point and then the mandible deviates to the right a slight amount.

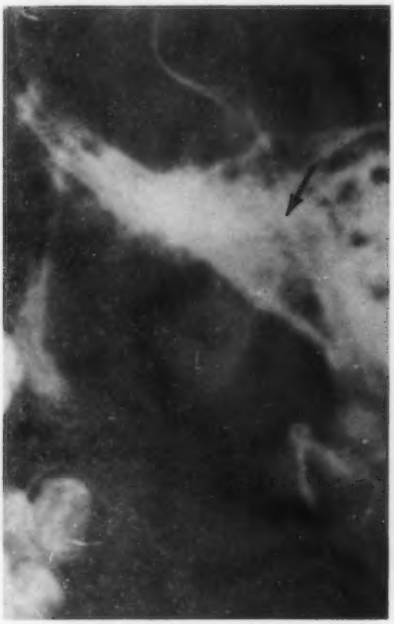


Fig. 3 New functioning condyle.

The treatment of this type fracture at this age is a very controversial subject. It is difficult to know whether or not open reduction of the fracture would have been a better treatment.

Figure 2 shows the photograph of the frontal headplate and the displacement of the right condyle into the infratemporal fossa.

Figure 3 shows the x-ray taken four years after the accident. Most condyles, which are completely dislocated from the ramus, resorb. The x-ray shows that a new functioning condyle has formed. It could be that there has been resorption of the old bone on the medial surface and new bone laid down on the lateral surface of the condyle according to the principle of Wolf's Law, or the original condyle resorbed and a new functioning pad of bone produced which permits a vertical movement.

Fig. 4 shows the frontal and profile photographs of the patient at ages 11 and 15 and no apparent deviation of mandibular growth.

I used acrylic bite planes in this case for two years. My purpose was to guide the mandible into occlusion and to relieve pressure in the affected joint. At the present time the midline is correct up to an opening of three-fourths inch, from there it deviates to the right and continues to open to more than one inch.

The basic problem in this fracture was the factor of future growth. The severe trauma received by the condyle in some fractures injures the growth center and circulation, and ankylosis of the joint may result. In this particular case I feel that the conservative treatment was satisfactory and that

Fig. 4 Photograph taken after treatment of fracture and photograph taken four years later.

open reduction was not indicated.

The finished photographs show that the small amount of growth lost due to the fracture at the g.owth site is not clinically noticeable.

It is my opinion that, unless the condyle is driven into the middle cranial fossa or into the external auditory meatus in fractures of the neck of the mandible, an open reduction should not be done. There is an occasional case in children that will develop an ankylosis, but I think this probably would occur even if an open reduction operation had been performed. Moreover, open reduction operations do not always give satisfactory results.

The conclusion that may be drawn in this case is that future growth was not as big a problem as first thought; at the age of 11 years future growth was not enough to cause noticeable asymmetry.

Case No. 3 was a young man, age 26, injured in an auto accident. He suffered fractures of both mandibular condyles, fracture through the right lower canine-incisor area, and fracture

Fig. 5 Photograph of x-ray showing tendency toward Class II occlusion with open bite. X-ray taken before complete reduction was accomplished.

Fig. 6 Photograph of x-ray showing complete fracture of maxilla.

of the mentale or chin portion of the mandible. This case is shown to point out the distal positioning of the mandible and the problem involved in reduction in order to avoid a Class II result with open bite.

Figure 5 shows the x-rays of the patient before complete reduction had been obtained. It also demonstrates the repositioning of mentale bone fragment due to the muscle function. This fragment was displaced downward. Many small bone fragments which, in the past, were removed because of fear of sequestration are molded back into position by the musculature.

Transverse Maxillary Fractures

Case No. 4 was an elderly gentleman age 76. He suffered a complete transverse fracture of the maxilla and zygomatic arches. The dentition consisted of the lower six anteriors and first bicuspids; in the maxillary arch only the six anteriors were present. Upon repositioning the maxilla it was found that he possessed a Class III occlusion with the upper left central, lateral, and canine occluding lingual to the lower

teeth. The complete maxilla was a floating section and was easily brought forward and held in occlusion (Fig. 6).

Due to the constant movement of the maxilla during deglutition, intermaxillary elastics were discontinued after the third day. From then on healing progressed slowly but nicely.

It might be stated at this time that the displacement of the maxilla in fracture cases is in the same direction as the force. In mandibular fractures the displacement of the fragments is due to the muscle attachments and their pull.

Of course, before one can consider reduction of fractures he must ascertain the type of occlusion the patient had originally. This is done through study of the x-rays, wear on teeth, photographs taken before the accident, and consultation with the family as to appearance.

This case is shown to point out the fact that after reduction of many fractures, fixation is not indicated. Slight movement of the fractured fragments does not seem to hinder union. However, greater movement seems to encourage soft connective tissue union and movement of the fragments may be permanent.

Mandibular Body Fractures

Case No. 5 was a young man presenting a fracture of the mandible just mesial to the third molar with the third molar in the distal fragment. It was determined that the most posterior tooth was a third molar through study of the tooth size and form, and the space between the first and third molar after reduction (Fig. 7).

The problem involved in this type of case is, naturally, lateral and vertical control of the distal fragment. Many methods of reduction and fixation have been suggested for control of the distal fragment (ramus) in mandibular

Fig. 7 Photograph of the x-ray showing fracture at the angle of the mandible.

fractures. Probably the first to be advanced was the plaster skullcap with heavy gauge wires running downward and connected by elastics to a pin inserted into the distal fragment. Another method is the surgically-placed bone plates as used in fractures of the lower extremities. However, one must remember that the orthopedic surgeon usually places a plaster cast on the plated leg to maintain immobility. This, of course, is impossible in facial fractures.

The extra-skeletal pin fixation appliance is also used. In this method small holes are drilled into the bone and threaded screw pins are screwed into the fragments and then joined together with sliding connecting bars. Anchorage of the pins is in the cortical plate. This plate, approximately two mm thick, is not the most reliable source of anchorage.

All three of these methods have the disadvantage of the necessity for surgically entering the soft and bony tissues. As bone resorbs in response to the slightest pressures, it is difficult to maintain fixation.

This fracture was reduced with complete edgewise orthodontic appliances with molar band attachments on the third molars. This attachment gives

exact control of the fragment.

Case No. 6 was that of a young man, age 28. He suffered fractures through the angle of the mandible between the second and third molar on the right and distal to the third molar on the left.

This fracture was reduced, as all have been, with only the edgewise orthodontic appliance with no attachment, arm, or pin connected to the distal portion of the left ramus. The third molar in the distal fragment on the right side was included in the fracture appliance. The free distal portion is brought into reduction by nature itself. Upon obtaining occlusion of the denture, the muscles relax from their trismatic tension to bring the fragments into normal apposition. When one considers that we have the massive masseter muscle on the outside and the internal pterygoid on the inside, the picture becomes clearer.

Figure 8 shows photographs of x-rays taken before and after reduction of the fracture.

Case No. 7 was a woman age 62. Injured in an automobile accident, she suffered a fracture of the right mandible at the angle distal to the first molar. There were no teeth present in the distal fragment.

She was first treated by extra-skeletal pin fixation. The pins became loose and the tissue infected due to the tension. Resorption of bone around the pins inserted into the bone is the problem of pin type appliance reduction. Interdental wiring was next tried, but didn't maintain stability.

I received the patient eight months following the accident in the condition shown in Figure 9, a photograph of the x-ray taken at the start of reduction. Complete edgewise appliances were used and reduction and fixation pro-

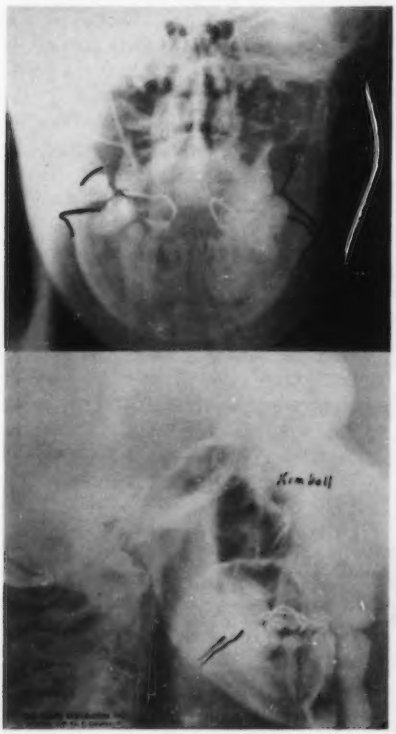


Fig. 8 Above, photogroph of x-ray taken before reduction; below, after reduction of fracture.

Fig. 9 Photograph of x-ray taken at the start of reduction.

ceeded without any problems. Again, no attachment was made to the distal free portion.

These last cases illustrate that it is not always necessary to insert attachments in the distal fragment of the mandible in order to accomplish reduction or apposition of the bony fragments. After the occlusal reduction has been accomplished, the masseter and external pterygoid muscles bring the distal segment into apposition and maintain it in that position during union.

Case No. 8 was a fracture case of a man, age 36, who had crashed in an airplane accident. His face smashed into the steering wheel and post. He suffered a crushed chest and fourteen facial fractures. There were fractures in the mandible between the canines and laterals on each side with a protrusion of the segment containing the lower incisor teeth. These teeth were forced completely through the lower lip. The maxilla was fractured completely loose from the basal support and contained an anteroposterior fracture along the middle of the palate; the upper left first and second molars with the alveolar process were fractured, the nasal bones were crushed. The upper left central was knocked out as was a bridge on the upper left side. Because of the fracture of the maxilla coordinate movement of the eyes was impossible.

A complete edgewise appliance was placed with arches to reduce the fractures. The mandibular arch was first reduced to have a base or foundation for the maxillary arch. Crisscross elastics were used in the buccal segments and vertical elastics in the anterior segment. After the lateral and vertical reduction had been corrected, physical force was necessary to bring the maxilla anteriorly to position. Then the vertical elastics were again used for fixation.

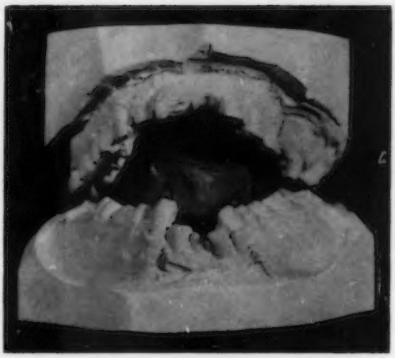


Fig. 10 Photograph of the plaster cast showing the occlusion immediately after the accident.

Simultaneously the plastic surgeon corrected the nasal bones. Not until we had the maxilla in complete reduction was proper coordination of the eyes possible.

Fortunately the patient's dentist had a plastic set of study models made a few weeks before the accident. These were used as a guide in reducing the fractures.

Now, five years later, the lower incisors are all vital.

Figure 10 is a photograph of the plaster cast of the occlusion immediately after the accident. Note the lingual inclination of the mandibular buccal segments and the anterior displacement of the lower incisal segment. In the upper arch one can see the upper left molar segment displaced to the buccal and the complete open bite in the anterior region.

Figure 11 shows the photographs of the original plastic model and the plaster cast made after completion of treatment. One can readily see that every segment was returned to its original position so that every tooth occluded as before the accident.

Summary

All the fracture cases were reduced

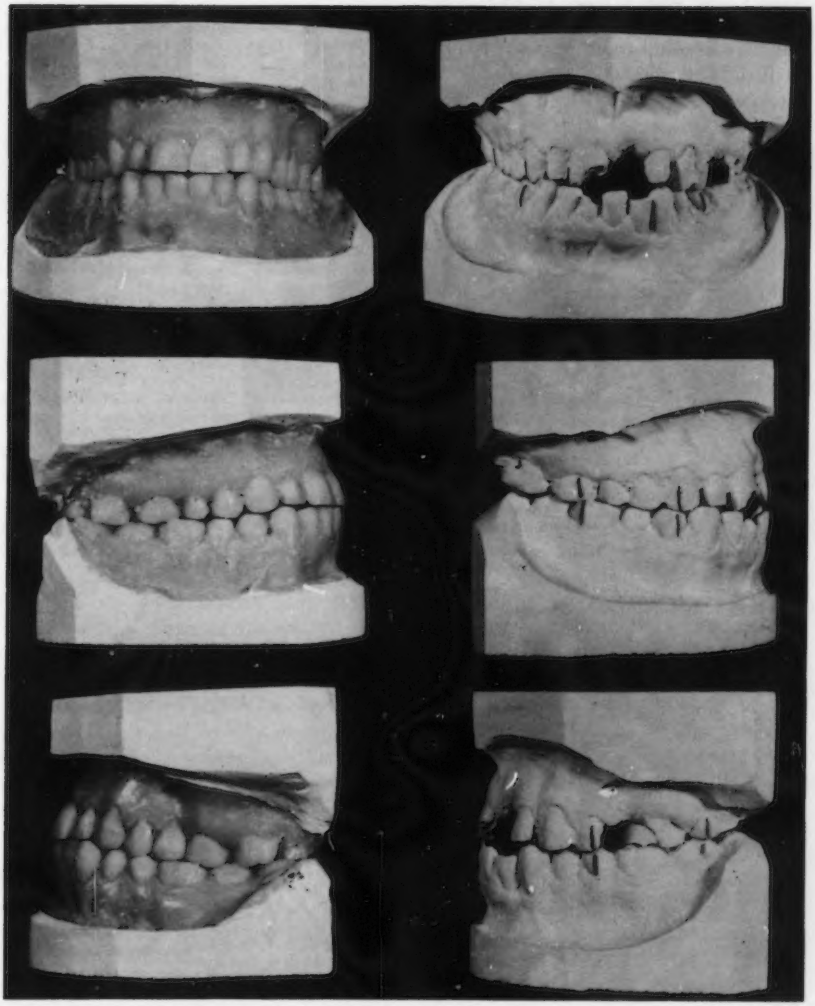


Fig. 11 Photographs of the plastic (before) and plaster (after) models showing the result of the fracture reduction.

with the edgewise appliance. I have never extracted a tooth before or during the reduction of a fracture nor have I ever used general or local anesthesia. All the work was done in the patient's hospital room with the patient in bed. The edgewise appliance is an ideal mechanism for the reduction of fractures because it is a precision appliance and one does not have to incise tissue or drill holes in the bone. No new avenues of infection are opened in order to accomplish the goal of fracture reduction, occlusion.

105 Washington Avenue

REFERENCES

Waldron, C. W.: Fractures of Mandible with Special Reference to Reduction of Complicated Displacements and Subsequent Immobilization. *J. Lancet* 62:228 June 1942

Ruedi, G: Zurklinik der Gelenkkoph Frakturen des Unterkiefers. Schweiz Manolf Zahnhke, 38:727, 805 1928

Steinhardt, G: Entschung, Heilung und Behanchlung des Luxation Frakturens Deutsch: Zahn Mund-u Kreferhlk, 3:662 1936

Perthes, I.: Neber Frakturen und Luxation Frakturen der Kuferkofchens und ihre Operative Behandlung. Verhandl. J. deutsch. Gesellsch. F. Chir., 1924, page 418

Brown, J. B. and Hamm, W. G.: Diagnosis and Treatment of Lesions Preventing Normal Opening of Mouth. *Intern. J. Ortho.* 18: 353 April 1932

Wassmund, M.: Neber Luxations Frakturen des Keefergelenkes. Deutsch Kuferchir 1: 27, 1934

Thoma, K. H.: Traumatic Injury of Condyloid Process of the Mandible, *Amer. J. Ortho.* 24:774 August 1938

Thoma, K. H.: Fractures and Fracture Dislocations of the Mandibular Condyle: A Method for Open Reduction and Internal Wiring and One for Skeletal Fixation, with a Report of Thirty-two Cases. *J. Oral Surgery.* Vol. 3, No. 1 Jan. 1945

Bellinger, D. H.: Henny, F. A. and Peterson, L. W.: Fractures of the Mandibular Condyle. *J. Oral Surgery* Vol. 1 1943

Henny, F. A.: A Technic for Open Reduction of Fractures of the Mandibular Condyle. *J. Oral Surgery* Vol. 9, 1951

Kloehn, Silas,: Application of Biological Principles to Treatment of Jaw Fractures. *Angle Ortho.* Vol. 10 April 1940

Jarabak, Joseph,: Subcondylar Fractures of the Mandible: Research and Treatment. *Amer. J. of Ortho.* Vol. 40, Oct. 1954

Thoma, Kurt H.: Methods of Fixation of Jaw Fractures and Their Indications. *J. Oral Surgery,* Vol. 6, 1948

Wright, Chester: Occlusal Reduction in Jaw Fracture Management. *Angle Ortho.* Vol. VII April 1937

Effect Of Vitamin C On The Mobility And Stability Of Guinea Pig Incisors Under The Influence Of Orthodontic Force

J. M. McCanlies, D.D.S. C. M. Alexander, D.D.S.
J. H. Robnett, D.D.S. W. B. Magness, D.D.S.
Houston, Texas

Loosening of the teeth has long been recognized as one of the signs of scurvy. This indicates that the surrounding tissues of the teeth are affected by a deficiency of vitamin C. The movement of teeth in orthodontics involves the resorption and rebuilding of the tissues supporting the teeth. The purpose of this study was to determine the correlation between the stability of orthodontically re-positioned teeth and the degree of vitamin C deficiency in experimental animals.

The guinea pig seems unable to store any more vitamin C than he uses in a short period of time. Other laboratory animals can evidently synthesize this substance in their bodies and, therefore, do not require it in their diet[1]. The length of time for the guinea pig to develop scurvy is only three weeks[4]. The age of the guinea pig also governs its susceptibility to scurvy; guinea pigs weighing from 110 to 250 grams succumb rapidly, while those weighing 300 to 500 grams withstand better the vitamin C deficiency[4]. The reported minimum requirement of ascorbic acid for growth varies greatly. This amount has been quoted as being anywhere from 0.4 mg. to 2 mg. per day. Waugh and King (1932) showed that 0.5 mg. per day was enough to protect guinea pigs against macroscopic scurvy. Zilva and Wells (1919) said that 2 mg. is essential for the prevention of microscopic changes in the parenchymal cells of the incisor roots. Some workers found higher needs.

Saturation of vitamin C is not a prerequisite for adequate nutrition, nor does it affect length of survival in scurvy. Zilva showed that 2 mg./day was adequate for normal growth, but 14 mg. in a single weekly dose was rapidly depleted and the animals showed inferior growth[6].

Many of the earlier studies reported in the literature on the effects of vitamin C deficiency are of little value, however, because the basal diets employed were markedly deficient in other factors as well as in vitamin C. This would make it impossible to attribute the findings to the lack of this vitamin alone[4].

When guinea pigs are given vitamin C deficient diets, impairment of physiologic functions can be demonstrated before growth is severely restricted or external evidences of scurvy appear[5]. Animals in such a border stage of deficiency are more sensitive to injury and infection. Normal metabolic activity as measured by dextrose tolerance is moderately lowered[8]. The arteries, teeth, and adrenals are particularly sensitive to injury by toxins.

The cells that make up the body tissues are cemented together by a material called the intercellular substance. This substance is not formed in the absence of ascorbic acid[1]. A controversial point has been whether ascorbic acid acts by (1) supplying a factor the cells need for the manufacture and control of intercellular substance, or (2) whether it produces its effect by direct

influence on the metabolism of the fibroblasts, osteoblasts, and odontoblasts (2). In guinea pigs depleted of ascorbic acid, the fibroblasts are present, just as in healthy pigs, but the fibrils and collagen fail to form. Within eighteen hours after adequate ascorbic acid dosage, these intercellular substances appear[2].

The cells in the regions of cessation of bone formation are frequently osteoblasts which have reverted to primitive fibroblasts. This condition suggests that in the absence of ascorbic acid the osteoblasts revert to their primitive tissue form and set up a fibrous union. It has also been suggested that the ascorbic acid may exert its effect indirectly by permitting normal metabolism of carbohydrates and protein (2).

Method and Materials

Twenty-one guinea pigs of equal age and approximately equal weight (350 gms) were used in this experiment. They were divided into four groups.

The animals were placed in individual cages and had food and water at all times. All four groups were fed Purina rabbit chow which contained no vitamin C but adequate amounts of all other essential nutrients[7].

Group I — five animals *without* appliances were given 1 mg. vitamin C per day to determine by comparison what influence the appliances would have on weight changes and also to serve as a general control group.

Group II — five animals *with* appliances were given 1 mg. vitamin C per day to serve as control for all the animals with appliances.

Group III — five animals *with* appliances were given .2 mg. vitamin C per day in an effort to establish a subclinical vitamin C deficiency group.

Group IV — six animals *with* appliances were given 0.0 mg. vitamin C per day to establish complete vitamin C deficiency.

Fig. 1

The animals were started on their diets fourteen days prior to placement of the appliances. The weights of the animals were recorded weekly.

The vitamin C solution was prepared fresh daily by dissolving 25 mgs. of vitamin C in 25 ml. of sweetened distilled water. The animals were fed orally with a calibrated syringe and feeding needle.

The lower incisors of the guinea pigs were selected for banding due to their greater length and accessibility (Fig. 1). The bands were made from .003″ x .125″ stainless steel orthodontic band material. The bands were preformed on the tapering shank of a dental hand instrument which was measured to approximate the size of the tooth and then spot-welded. Stainless steel loops (eyelets) were spot-welded on the labial surfaces of the bands in such a manner that a small wire could be passed freely through the eyelets on both teeth at right angles to the long axis of the teeth. The bands were then cemented into place with zinc oxyphosphate cement (Fig. 2). It was found to be unnecessary to anesthetize the animals for any appliance manipulation.

Measurements were made from the distal of the right lower central to the distal of the left lower central at the

Fig. 2

level of the center of the bands. The amount of tooth separation was determined by subtracting the distance across the banded teeth when together from the distance across the teeth after they had been separated.

Measurements were taken daily and immediately before and after any appliance changes.

Orthodontic coil springs were used to separate the teeth. These coil springs were stock .009 x .032. The coil springs were made as nearly identical as possible using five loops in the initial separation. These coil springs were compressed between the eyelets, then a small (.016″) stainless steel wire was passed through eyelet, coil spring, and eyelet in that order. This wire was then crimped over on the ends to prevent its loss (Fig. 3). After the initial coils had expanded to their limit and the teeth given time to stabilize, they were replaced by longer coils of eight loops each (Fig. 4). These coils were left in place until they had accomplished all the movement possible and the teeth in Groups II and III appeared stable; then the springs and holding wire were removed and the teeth were allowed to return to their original positions.

The experiment was conducted over a period of thirty-nine days.

Results

Separation

The appliances were placed and separation of the teeth was begun two weeks after initiating the diets.

The first signs of weight loss appeared in Group IV and, shortly thereafter, in Group III. This weight loss was first evident during the third week of the experiment (Graph 1).

There were no significant differences in the rate and amount of separation of the incisors in the three groups throughout the separation period (Graph 2). Total separation was approximately equal in all groups immediately prior to band removal. The teeth in the group receiving no vitamin C were quite mobile and the animals showed

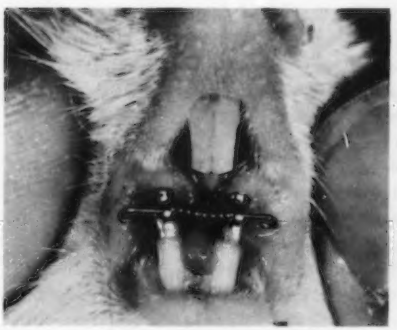
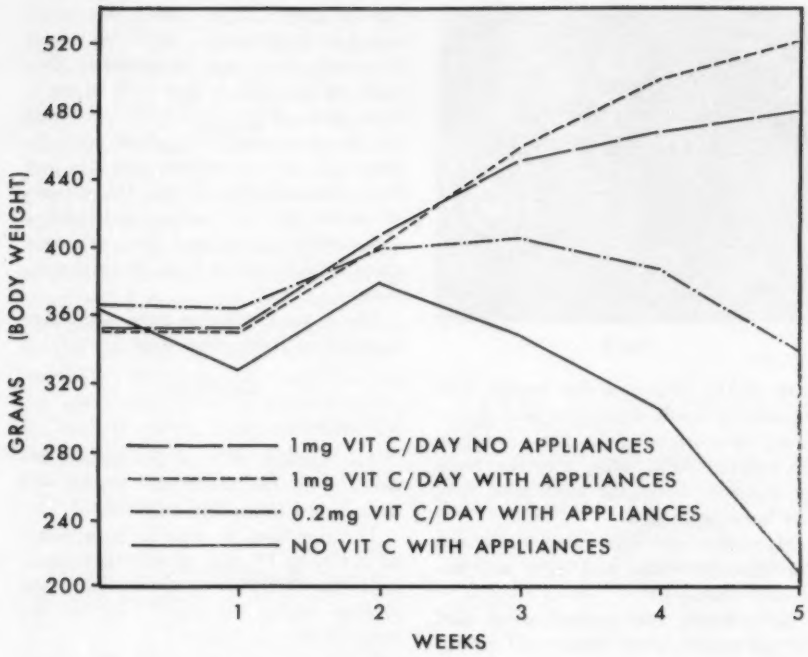


Fig. 3

Fig. 4



Graph 1

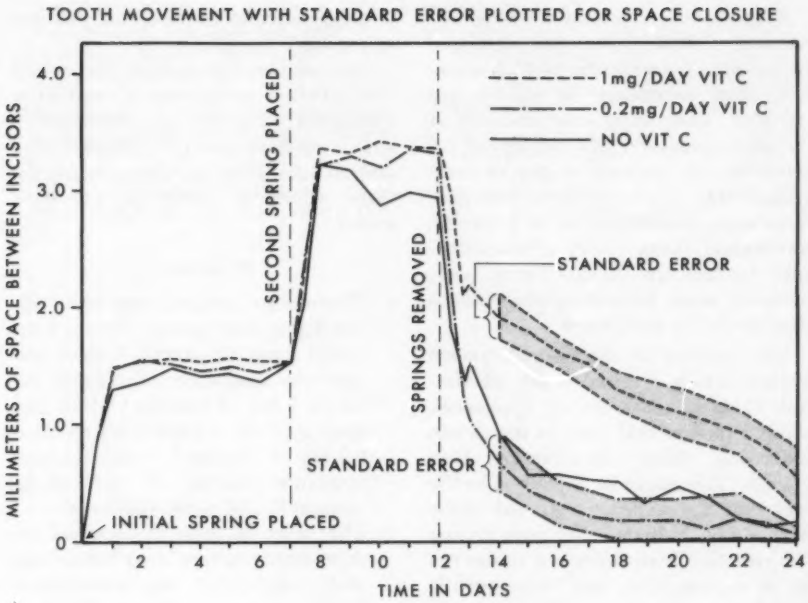
signs of severe scurvy. The animals in the Group III (0.2 mg.) also exhibited signs of scurvy although not quite as severe as the Group IV (0.0). There was no significant difference in the weights and general appearance of Groups I and II indicating that the appliances had no effect on rate of weight gain. Both groups gained weight and remained healthy throughout the experiment. Those animals in the last two groups began showing weight loss during the third week after being put on the vitamin C deficient diet and continued to show weight loss throughout the experiment.

Relapse

After the appliances were removed, the teeth in all groups began to return to their original positions. The speed of the relapse was more rapid in Groups III and IV as compared with Group II (See Graph 2). One standard error was plotted on the graph for Groups II and III. This indicates that the difference in rate of relapse was significant.

Discussion

The fact that the rate of separation of the teeth in Groups II, III, and IV was equal probably is the result of the appliance used. The severity of the force exerted is apparent when it is realized that separation was completed within twenty-four hours after the springs were placed. From the results of this experiment it would be difficult to conclude that there was an increase in osteoclastic activity due to vitamin C deficiency; however, the results do not contradict the work done by Hunt and Paynter[3] who found increased osteo-



Graph 2

clastic activity during vitamin C deficiency in guinea pigs.

The difference in rates of relapse between Groups II, III, and IV must be explained on the basis of interference with fibroblastic and osteoblastic activity in the vitamin C deficient groups. The surprising factor was the almost immediate relapse of the subacute scorbutic group (Group III). The production of clinical scurvy instead of subclinical scurvy was a disappointment. Further investigation to determine the effects of subclinical vitamin C deficiency on tooth movement and retention should be done using levels of 0.2 to 0.5 mg. of ascorbic acid per day.

The severe deficiency produced in Group IV (no vitamin C supplement) resulted in the death of all but two of the animals by the end of the experiment. It is of interest to note, however, the almost identical rate of space closure in Groups III and IV even though Group III had comparatively mild vitamin C deficiency.

Histological Sections

An animal was sacrificed from each of the four groups previously mentioned when the spaces between the lower incisors had closed and the experiment terminated. The anterior half of the lower jaw was removed and placed immediately in a fixative of 10% formalin. These tissues, which included the lower incisors with adjacent bone and connective tissues, were then sent to the laboratory for histological sectioning.

The sections were taken in a frontal vertical plane along the long axis of the incisors in an attempt to show both incisors with bone and connective tissues interproximally. The sections were stained with hemotoxin and eosin.

Representative sections were mounted and examined by two unbiased pathologists individually, both of whom have had experience in guinea pig research. These men were unaware of the diet or orthodontic treatment received by the animals in any of these groups. The results of these examinations were inconclusive as to a specific histological entity found characteristically in any one group. There were, however, some interesting observations that should be mentioned.

The sections of the normal control animal, which received 1 mg. of vitamin C daily and wore no appliances, showed incremental lines in the dentin indicating some interference with growth. This might be explained by the fact that the animals were fed orally once a day. Although they were getting the vitamin C requirements, it was not in a regular diet and consequently could have had some effect on the growth of the dentin.

Sections of the animals that received normal amounts of vitamin C (1 mg. daily) and wore appliances also showed these incremental lines. The pulp also seemed to show more osteodentin which might possibly be the result of the tooth movement since this was not seen in the above-mentioned sections. No resorption areas were noticed. Although these teeth were moved, it seems that the tissues had repaired.

The animals in the group that received .2 mg. of vitamin C daily and wore appliances showed osteodentin as in the above. Large resorption lacunae with osteoclasts were present which might indicate an impairment in the reparative process due to the vitamin C deficiency. It is interesting to note that the animals receiving 1 mg. of vitamin C daily did not show this although they also were subjected to tooth movement. Hemorrhage in the tissues was noted and could also be attributed to vitamin C deficiency and the resulting increase in capillary fragility.

The section representing the group that received no vitamin C and wore appliances showed a considerable amount of bone resorption, hemorrhage and an edematous condition in all the tissue which is indicative of acute scurvy.

Summary

1. Twenty-one guinea pigs were divided into four groups. Group I received 1 mg. of vitamin C daily and wore no appliances. Group II received 1 mg. of vitamin C daily and wore appliances. Group III received 0.2 mg. of vitamin C daily and wore appliances, Group IV received no vitamin C and wore appliances.
2. The animals were maintained on their diets fourteen days before any tooth movement was undertaken. There was no significant difference in rate of weight increase between Group I and II indicating that the appliances had no effect on food intake.
3. The rates of separation and the amount of separation of the lower incisors were approximately equal in Groups II, III, and IV.
4. After the appliances were removed, the teeth in animals of Groups III and IV returned to their original positions more quickly than did the teeth in animals of Group II.

Univ. of Texas Dental Branch

1. Arnow, Earle — *Physiological and Pathological Chemistry*, St. Louis, Missouri, C. V. Mosby Co., 1953
2. Eddy, Walter H. — *Vitaminology*, Baltimore, Maryland, Williams and Wilkins, 1949.
3. Hunt, A. M. and Paynter, K. J. — "Effects of Ascorbic Acid Deficiency on the Teeth and Periodontal Tissues of Guinea Pigs," *J. of Dent. Res.*, 38: 232, 1959
4. Sherman, H. C. and Smith, S. L. — *The*

Vitamins, 2nd Edition, New York, N.Y., The Chemical Catalogue Co., 1931

5. American Medical Association — *The Vitamins*, Chicago, Ill., The Association, 1939
6. Mannereteg, G. I. — "Vitamin C Requirements of the Guinea Pig," *Vitamins and Hormones*, III: 202, 1949
7. Hawk, P. B., Oser, B. L., Summerson, W. H. — *Practical Physiological Chemistry*, New York, N.Y., McGraw and Hill, 1239, 1954
8. Lyman, C. M., and King, C. G. — "The Effect of Diphtheria Toxin on the Vitamin C Content of Guinea Pig Tissues," *J. of Pharm. and Exp. Ther.*, 56: 209, Feb., 1936
9. Sigal, Alex, and King, C. G. — "The Influence of Vitamin C Deficiency Upon the Resistance of Guinea Pigs to Diphtheria Toxin," *J. of Pharm. and Exp. Ther.*, 61: 1-9, Sept., 1937

Frederick Bogue Noyes

In his modest home at Lake Worth, Florida, Frederick Noyes died suddenly and painlessly at the age of eighty-nine years. Throughout his lifetime he had, as he often said, been "disgustingly healthy" and he was spared a long and agonizing terminal illness.

The stature of this man is simply expressed in a sentence which Isaac Schour wrote at the time of a banquet honoring him when he became Dean Emeritus of the College of Dentistry, University of Illinois. He said, "His scientific achievements, outstanding as they are, represent only one part of the full strength of the man." Contained in the many letters of sympathy written after Dr. Noyes' death there runs a strong and unmistakable theme of appreciation of his personal interest and kindly understanding, particularly of younger men whose lives touched his. He could be adamant and vitriolic in his defense of principles, academic and professional, in which he believed, yet generous and gracious to those whom he felt held genuine and honest differences with his own convictions.

His interest in sailing was generated at the age of ten when his father, Edmund Noyes, a dental practitioner and teacher in Chicago, permitted him to spend a summer on the St. Lawrence River. For many years he sailed and raced at Delavan Lake, beginning when he rigged a large row boat with a sail which his mother made for it and won the first sailboat race on that lake. Sailing, he believed, was not only a fascinating sport, but developed the qualities of observation, quick judgment, and nicety of manipulation, all of which he demonstrated in other areas of his work and interests.

In 1889 Edmund Noyes sent his son to Beloit Academy. He was the smallest boy in his class and the only one still wearing short trousers. On one occasion Fred carried a football the length of the field and thereafter was dubbed "Pants" by his fellow students, those playing on the opposite team, no doubt.

After attending the College of Liberal Arts and Sciences, Johns Hopkins University, Dr. Noyes received a B.A. degree in 1893. Here he majored in biologic and physical science with his principal interest in histology. His athletic activities were in the gymnasium where he was a member of the gym team and, because of his stature, top man on pyramid formations.

As a student at Northwestern University Dental School, Frederick Noyes assisted in teaching histology. Upon graduation in 1895, in addition to the general practice of dentistry he organized the first course in Dental Histology in the United States and wrote the first textbook dealing with that subject. He was motivated and assisted by Dr. Greene Vardiman Black for whom Dr. Noyes prepared most of the illustrations for Black's *Operative Dentistry and Special Dental Pathology.* The friendship of these men grew through the years notwithstanding the difference in their ages. One of the most informative and interesting accounts of G. V. Black's life is contained in Dr. Noyes' presidential address to the Institute of Medicine in Chicago.

Two years after receiving his dental degree Frederick Noyes married Mary Ellen Judd. Dr. Noyes' human interest and understanding was excelled only by that of his wife. No one who did not know both intimately could fully appreciate the contribution which she made to his further growth, advancement and contentment. There were two

children by this marriage, Harold, now living in Portland, Oregon, and Frederick, in Miami, Florida. The mother of these boys died shortly after her fiftieth wedding anniversary. Before retiring and leaving his home in Park Ridge, Illinois, Dr. Noyes married Martha McNicoll, who survives him.

The interest of Frederick Noyes in orthodontia and his friendship with Edward H. Angle began in 1904 when Angle interested the young histologist in teaching that subject in the postgraduate course which Dr. Angle conducted in this special field of dentistry. Here Dr. Noyes met many earnest students who were to become not only his colleagues but close friends in years to come. His orthodontic interest was so stimulated with this experience that in 1908 Noyes took the Angle course and upon its completion limited his practice to orthodontia.

Five years later Dr. Noyes left Northwestern University Dental School to become Professor and Head of the Departments of Dental Histology and Orthodontia, University of Illinois. In 1921 his academic responsibilities were limited to the latter department and in 1926 he became Dean of the College of Dentistry. The pattern of practically all university orthodontic education has followed the concept of graduate school training as established by Dr. Noyes at Illinois in 1930.

The clinical, scientific and academic contributions of Frederick Noyes have received recognition by the Sc.D. degree from Northwestern University in 1922, the Callahan Medal presented by Ohio State Dental Society in the same year, the Jarvey Medal he received from the New York State Dental Society in 1929, the Ketcham Memorial Award of the American Association of Orthodontists, 1941, the L.L.D. degree from Temple University, and perhaps most important, the admiration, love and affection held in the hearts of students, colleagues and friends.

Book Review

INTRODUCTION TO ORTHODONTICS
Anders Lundstrom, et al., 315 pages, with 246 figures. McGraw-Hill Book Co., Inc., New York, 1960.

Originally published in Sweden in 1958 by a team of Scandinavian authors, this translated text was written for an undergraduate course in orthodontics and as an introduction for graduate students in this field.

In their countries the undergraduate orthodontic course is given more time and consideration than is the case of many other countries including the United States. It is felt that a fairly thorough grounding in orthodontic theory and practice is an essential part of the general dental training for only then will the family dentist be in a position to follow intelligently the developing dentitions of his young patients and recognize at an early age deviations that might call for interceptive treatment, if not for measures of a more complicated nature.

True, as editor Lundstrom remarks, no section on the construction of orthodontic appliances has been included. However, almost one-third of the book is devoted to methods of treatment and treatment of various forms of malocclusion. As might be expected, mechanical treatment through the use of the Andresen activator or other removable devices is described in detail.

Pre and postnatal development of the face and dentition is reviewed fully by three authors. Bjork has a chapter devoted to the relationship of the jaws to the cranium. The etiology, prevention and incidence of malocclusion are discussed by Lundstrom, and Reitan has an excellent chapter on tissue reactions to orthodontic tooth movement.

The illustrations are numerous and the engraving of the finest quality. Despite the fact that this collaborative book by nine authors was written expressly for the undergraduate student, it contains much of interest to the practicing orthodontist of this country. While not recent, many of the references will be new to Americans, most of whom are only scarcely acquainted with orthodontic literature other than that published in the United States.

A. B. L.

The Angle Orthodontist

A magazine established by the co-workers of Edward H. Angle, in his memory . . .

Editor: Arthur B. Lewis.

Business Manager: Silas J. Kloehn.

Associate Editors: Allan G. Brodie, Morse R. Newcomb, Harold J. Noyes, Robert H. W. Strang, Wendell L. Wylie.

Vol. XXXI, No. 4 October, 1961

Index to Authors

B

Baldridge, J. Philip, Unilateral Action with Headcap, p. 63, January.

Berger, H., Problems and Promises of Basilar View Cephalograms, p. 237, October.

Bergersen, Earl O., A Comparative Study of Cephalometric Superimposition, p. 216, October.

Bradley, R. E., The Relationship Between Eruption, Calcification and Crowding of Certain Mandibular Teeth, p. 230, October.

Buchner, Howard J., Orthodontic Case Analysis, p. 157, July.

Burstone, C. J., Baldwin, J. J., and Lawless, D. T., The Application of Continuous Forces to Orthodontics, p. 1, January.

C

Coben, S. Eugene, Growth Concepts, p. 194, July.

Craven, Arthur H., Highlights in Recent Foreign Literature, p. 123, April.

Crutcher, Fred F., Harmonious Anthropometric Relationships, p. 18, January.

F

Fleming, Harry B., An Investigation of the Vertical Overbite During the Eruption of the Permanent Dentition, p. 53, January.

G

Green, Larry J., The Interrelationships among Height, Weight and Chronological, Dental and Skeletal Ages, p. 189, July.

H

Haas, Andrew J., Rapid Expansion of the Maxillary Dental Arch and Nasal Cavity by Opening the Midpalatal Suture, p. 73, April.

K

Kloehn, S. J., Evaluation of Cervical Anchorage Force in Treatment, p. 91, April.

L

Lifschiz, Julian M., A Comparison of Upper First Molar Rotation in Class II, Division I and Class I, p. 202, July.

M

Mathews, J. Rodney, Clinical Management and Supportive Rationale in Early Orthodontic Therapy, p. 35, January.

McCanlies, J. M., Alexander, C. M., Robnett, J. H. and Magness, W. B., Effect of Vitamin C on the Mobility and Stability of Guinea Pig Incisors Under the Influence of Orthodontic Force, p. 257, October.

R

Ricketts, Robert M., Cephalometric Analysis and Synthesis, p. 141, July.

S

Schoenwetter, Robert F., Reduction and Fixation of Facial Fractures, p. 246, October.

Steadman, S. R., Changes of Intermolar and Intercuspid Distances Following Orthodontic Treatment, p. 207, October.

Strang, Robert H. W., Discussion of the Newer Trends and Techniques, p. 184, July.

Subtelny, J. Daniel, The Soft Tissue Profile, Growth and Treatment Changes, p. 105, April.

T

Thompson, John R., Function and Growth, p. 132, April.

Thurow, Raymond C., The Decimal Calendar, p. 69, January.

V

Valinoti, Joseph R., Case Report, p. 15, January.

Index

Analysis:

Orthodontic Case Analysis, Howard J. Buchner, p. 157, July.

A Comparison of Upper First Molar Rotation in Class II, Division I and Class I, Julian M. Lifschiz, p. 202, July.

Book Review:

Introduction to Orthodontics, Lundstrom, et al., Arthur B. Lewis, p. 266, October.

Case Report:

Case Report, Joseph R. Valinoti, p. 15, January.

Cephalometrics:

Problems and Promises of Basilar View Cephalograms, H. Berger, p. 237, October.

A Comparative Study of Cephalometric Superimposition, Earl O. Bergersen, p. 216, October.

Growth Concepts, S. Eugene Coben, p. 194, July.

Cephalometric Analysis and Synthesis, Robert M. Ricketts, p. 141, July.

Dental Development:

The Relationship Between Eruption, Calcification and Crowding of Certain Mandibular Teeth, R. E. Bradley, p. 230, October.

An Investigation of the Vertical Overbite During the Eruption of the Permanent Dentition, Harry B. Fleming, p. 53, January.

The Interrelationships among Height, Weight and Chronological, Dental and Skeletal Ages, Larry J. Green, p. 189, July.

Function:

Function and Growth, John R. Thompson, p. 132, April.

Mechanics:

The Application of Continuous Forces to Orthodontics, C. J. Burstone et al., p. 1, January.

Effect of Vitamin C on the Mobility and Stability of Guinea Pig Incisors Under the Influence of Orthodontic Force, J. M. McCanlies, et al., p. 257, October.

Discussion of the Newer Trends and Techniques, Robert H. W. Strang, p. 184, July.

Miscellaneous:

Highlights in Recent Foreign Literature, Arthur H. Craven, p. 123, April.

Reduction and Fixation of Facial Fractures, Robert F. Schoenwetter, p. 246, October.

The Decimal Calendar, Raymond C. Thurow, p. 69, January.

Obituary:

Frederick Bogue Noyes, p. 264, October.

Soft Tissue:

The Soft Tissue Profile, Growth and Treatment Changes, J. Daniel Subtelny, p. 105, April.

Treatment:

Unilateral Action with Headcap, J. Philip Baldridge, p. 63, January.

Rapid Expansion of the Maxillary Dental Arch and Nasal Cavity by Opening the Midpalatal Suture, Andrew J. Haas, p. 73, April.

Evaluation of Cervical Anchorage Force in Treatment, S. J. Kloehn, p. 91, April.

Clinical Management and Supportive Rationale in Early Orthodontic Therapy, J. Rodney Mathews, p. 35, January.

Changes of Intermolar and Intercuspid Distances Following Orthodontic Treatment, S. R. Steadman, p. 207, October.

The Angle Orthodontist

Instructions to Contributors

The author should submit the original typed copy of the manuscript, double-spaced on bond paper. The author's name and city of residence should appear immediately after the title, and the street address should appear at the end of the article.

Do not use symbols to indicate teeth; in *tables* teeth may be designated as U-1 or L-6, but in the text names of teeth should be fully written out.

Line drawings should be prepared in India ink on white stock; the width of lines and the size of lettering should take into account the fact that most illustrations are reduced in size in the engraving process. Photographs should be sharp, glossy prints of adequate size, *unmounted and kept separate from the text*. At the discretion of the editor, illustrations will be reproduced either as single column cuts of approximately 2¼ inches in width, or as double column cuts of 4¾ inches in width. The height of the cut may vary, but contributors should keep in mind that proportionate reduction or enlargement of illustrations affects all dimensions, and that arrangement of material should be such that awkward proportions are avoided and no loss of clarity results.

The Frankfort plane should appear in cephalometric tracings, and wherever possible should provide the basis of orientation of illustrative matter portraying the face, whether it be films, tracings or facial photographs. All material must be positioned with the facial profile on the right.

Extraneous details should be eliminated from illustrative matter in order to keep the salient portions of the cut as large as possible, i.e., the cranial outline should be eliminated from cephalometric tracings unless its omission would be detrimental to the sense of the article, photographs of patients should be cropped closely, and photographs of models should be separated by a minimal amount of empty space. Illustrations will be returned to authors for revision when they do not comply with these specifications.

Editor
Arthur B. Lewis
804 Hulman Bldg.
Dayton 2, Ohio

Business Manager
Silas J. Kloehn
Zuelke Building
Appleton, Wisconsin